Question Papers of IIT JEE Physics

Year-wise (1978–2018) Papers with Answers

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Preface

This book provides a comprehensive collection of IIT JEE physics papers. We have tried our best to generate authentic and 'close to the original' papers. They can be used for practice and revision.

The question papers are arranged in reverse chronological order i.e., latest first. For each year, the examination format is described in brief. The type of questions asked in each paper and the marking schemes are also described (wherever possible).

Each question starts on a new page. This provide examination like environment (computer based test).

Answers are provided at the end of each paper. This will help in self evaluation. To us, every problem, is a valuable resource to unravel a deeper understanding of the underlying physical concepts. We believe that getting the right answer is often not as important as the process followed to arrive at it.

If a student seriously attempts all the problems in this book, he/she will naturally develop the ability to analyze and solve complex problems in a simple and logical manner using a few, well-understood principles.

The IIT JEE problems fall into one of the nine categories: (i) MCQ with single correct answer (ii) MCQ

with one or more correct answers (iii) Paragraph based (iv) Assertion Reasoning based (v) Matrix matching (vi) True False type (vii) Fill in the blanks (viii) Integer Type, and (ix) Subjective. Each paper has sections according to the categories.

If you can't solve a problem, give it a retry before referring to the solution. This will help you identify the critical points in the problems, which in turn, will accelerate the learning process.

We would be glad to hear from you for any suggestions/corrections on the improvement of the book. This book has a companion website, www.concepts-of-physics.com.

Many friends and colleagues have contributed greatly to the quality of this book. First and foremost, we thank Dr. H. C. Verma, who was the inspiring force behind this project. Our close friends and classmates from IIT Kanpur, Deepak Sharma, Chandrashekhar Kumar and Akash Anand stood beside us throughout this work. This work would not have been possible without the constant support of our wives Reena and Nandini and children Akshaj, Viraj and Maitreyi.

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Contents

IIT JEE 2018

IIT JEE 2018 was a two stage examination (i) JEE Mains by CBSE and (ii) JEE Advanced by JAB. There were two papers in JEE Advanced, namely (Advanced) Paper 1 and (Advanced) Paper 2. Each of the papers has three separate parts for physics, chemistry and mathematics. JEE Advanced was a computer based test.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

(Advanced) Paper 1

The physics part of the paper contains 18 questions of total marks 60. The questions are divided into three sections (1) multiple correct answers type (2) numerical type and (3) paragraph type.

One or More Option(s) Correct

This section contains 6 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. For each question, choose the correct option(s) to answer the question. Answer to each question will be evaluated according to the following marking scheme:

1. Full Marks: (+4) If only (all) the correct option(s) is (are) chosen.
2. Partial Marks: (+3) If all the four options are correct but only three options are chose.
3. Partial Marks: (+2) If three or more options are correct but only two options are chosen, both of which are correct options.
4. Partial Marks: (+1) If two or more options are correct but only one option is chosen and it is a correct option.
5. Zero Marks: (0) If none of the options is chosen (i.e., the question is unanswered).
6. Negative Marks: (−2) In all other cases

For example, if first, third and fourth are the ONLY three correct options for a question with second option

being an incorrect option; selecting only all the three correct options will result in +4 marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in +2 marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in +1 marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in −2 marks.

Q 1. The potential energy of a particle of mass m at a distance r from a fixed point O is given by $V(r) = kr^2/2$, where k is a positive constant of appropriate dimensions. This particle is moving in a circular orbit of radius R about the point O. If v is the speed of the particle and L is the magnitude of its angular momentum about O, which of the following statement(s) is (are) true?

(A) $v = \sqrt{\frac{k}{2m}}R$ (B) $v = \sqrt{\frac{k}{m}}R$

(C) $L = \sqrt{mk}R^2$ (D) $L = \sqrt{\frac{mk}{2}}R^2$

Q 2. Consider a body of mass 1.0 kg at rest at the origin at time $t = 0$. A force $\vec{F} = (\alpha t\,\hat{\imath} + \beta\,\hat{\jmath})$ is applied on the body, where $\alpha = 1.0$ N/s and $\beta = 1.0$ N. The torque acting on the body about the origin at time $t = 1.0$ s is $\vec{\tau}$. Which of the following statements is (are) true?

(A) $|\vec{\tau}| = \frac{1}{3}$ N m

(B) The torque $\vec{\tau}$ is in the direction of the unit vector $+\hat{k}$

(C) The velocity of the body at $t = 1$ s is $\vec{v} = \frac{1}{2}(\hat{\imath} + 2\hat{\jmath})$ m/s

(D) The magnitude of displacement of the body at $t = 1$ s is $1/6$ m

Q 3. A uniform capillary tube of inner radius r is dipped vertically into a beaker filled with water. The water rises to a height h in the capillary tube above the water surface in the beaker. The surface tension of water is σ. The angle of contact between water and the wall of the capillary tube is θ. Ignore the mass of water in the meniscus. Which of the following statements is (are) true?

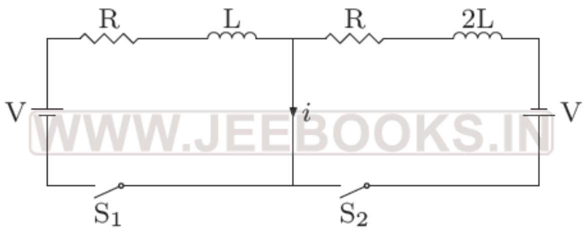
(A) For a given material of the capillary tube, h decreases with increase in r.

(B) For a given material of the capillary tube, h is independent of σ.

(C) If this experiment is performed in a lift going up with a constant acceleration, then h decreases.

(D) h is proportional to contact angle θ.

Q 4. In the figure below, the switches S_1 and S_2 are closed simultaneously at $t = 0$ and a current starts to flow in the circuit. Both the batteries have the same magnitude of the electromotive force (*emf*) and the polarities are as indicated in the figure. Ignore mutual inductance between the inductors. The current i in the middle wire reaches its maximum magnitude $i_{\max}$ at time $t = \tau$. Which of the following statements is (are) true?



(A) $i_{\max} = \frac{V}{2R}$ (B) $i_{\max} = \frac{V}{4R}$
(C) $\tau = \frac{L}{R}\ln 2$ (D) $\tau = \frac{2L}{R}\ln 2$

Q 5. Two infinitely long straight wires lie in the x-y plane along the line $x = \pm R$. The wire located at $x = +R$ carries a constant current i_1 and the wire located at $x = -R$ carries a constant current i_2. A circular loop of radius R is suspended with its centre at $(0, 0, \sqrt{3}R)$ and in a plane parallel to the x-y plane. This loop carries a constant current i in the clockwise direction as seen from above the loop. The current in the wire is taken to be positive if it is in the $+\hat{\jmath}$ direction. Which of the following statements regarding the magnetic field $\vec{B}$ is (are) true?

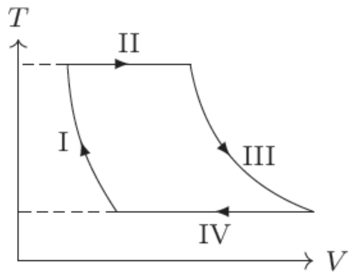
(A) If $i_1 = i_2$, then $\vec{B}$ *cannot* be equal to zero at the origin $(0, 0, 0)$.

(B) If $i_1 > 0$ and $i_2 < 0$, then $\vec{B}$ can be equal to zero at the origin $(0, 0, 0)$.

(C) If $i_1 < 0$ and $i_2 > 0$, then $\vec{B}$ can be equal to zero at the origin $(0, 0, 0)$.

(D) If $i_1 = i_2$, then the z-component of the magnetic field at the centre of the loop is $\left(-\frac{\mu_0 i}{2R}\right)$.

Q 6. One mole of a monatomic ideal gas undergoes a cyclic process as shown in the figure (where V is the volume and T is the temperature). Which of the statements below is (are) true?



(A) Proecess I is an isochoric process.
(B) In process II, gas absorbs heat.
(C) In process IV, gas releases heat.
(D) Process I and III are *not* isobaric.

Integer Type

This section contains 8 questions. The answer to each question is a numerical value. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. Answer to each question will be evaluated according to the following marking scheme:

1. Full Marks: (+3) If only the correct numerical value is entered as answer.
2. Zero Marks: (0) In all other cases.

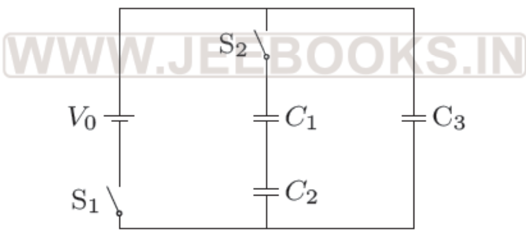
Q 7. Two vectors $\vec{A}$ and $\vec{B}$ are defined as $\vec{A} = a\,\hat{\imath}$ and $\vec{B} = a\,(\cos\omega t\,\hat{\imath} + \sin\omega t\,\hat{\jmath})$, where a is a constant and $\omega = \pi/6$ rad/s. If $|\vec{A}+\vec{B}| = \sqrt{3}\,|\vec{A}-\vec{B}|$ at time $t = \tau$ for the first time, the value of τ, in *seconds*, is ....

Q 8. Two men are walking along a horizontal straight line in the same direction. The man in front walks at a speed 1.0 m/s and the man behind walks at a speed 2.0 m/s. A third man is standing at a height 12 m above the same horizontal line such that all three men are in a vertical plane. The two walking men are blowing identical whistles which emit a sound of frequency 1430 Hz. The speed of sound in air is 330 m/s. At the instant, when the moving men are 10 m apart, the stationary man is equidistant from them. The frequency of beats in Hz, heard by the stationary man at this instant, is ....

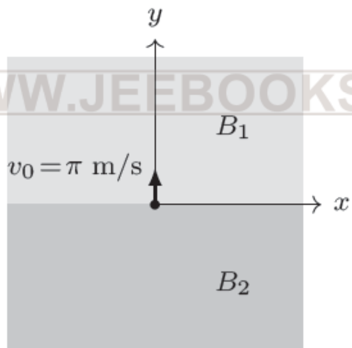
Q 9. A ring and a disc are initially at rest, side by side, at the top of an inclined plane which makes an angle 60° with the horizontal. They start to roll without slipping at the same instant of time along the shortest path. If the time difference between their reaching the ground is $(2-\sqrt{3})/\sqrt{10}\,\mathrm{s}$, then the height of the top of the inclined plane, in *metres*, is .... [Take $g = 10\ \mathrm{m/s^2}$]

Q 10. A spring-block system is resting on a frictionless floor as shown in the figure. The spring constant is 2.0 N/m and the mass of the block is 2.0 kg. Ignore the mass of the spring. Initially the spring is in an unstretched condition. Another block of mass 1.0 kg moving with a speed of 2.0 m/s collides elastically with the first block. The collision is such that the 2.0 kg block does not hit the wall. The distance, in *metres*, between the two blocks when the spring returns to its unstretched position for the first time after the collision is ....

Q 11. Three identical capacitors C_1, C_2 and C_3 have a capacitance of 1.0 μF each and they are uncharged initially. They are connected in a circuit as shown in the figure and C_1 is then filled completely with a dielectric material of relative permittivity ϵ_r. The cell electromotive force (*emf*) is $V_0 = 8$ V. First the switch S_1 is closed while the switch S_2 is kept open. When the capacitor C_3 is fully charged, S_1 is opened and S_2 is closed simultaneously. When all the capacitors reach equilibrium, the charge on C_3 is found to be 5 μF. The value of $\epsilon_r = \ldots\ldots\ldots$

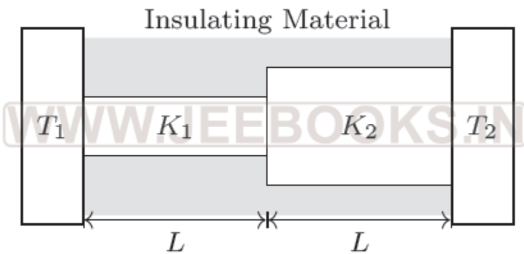


Q 12. In the x-y plane, the region $y > 0$ has a uniform magnetic field $B_1\,\hat{k}$ and the region $y < 0$ has another uniform magnetic field $B_2\,\hat{k}$. A positively charged particle is projected from the origin along the positive y-axis with speed $v_0 = \pi$ m/s at $t = 0$, as shown in the figure. Neglect gravity in this problem. Let $t = T$ be the time when the particle crosses the x-axis from below for the first time. If $B_2 = 4B_1$, the average speed of the particle, in m/s, along the x-axis in the time interval T is ....



Q 13. Sunlight of intensity $1.3\,\mathrm{kW/m^2}$ is incident normally on a thin convex lens of focal length 20 cm. Ignore the energy loss of light due to the lens and assume that the lens aperture size is much smaller than its focal length. The average intensity of light, in $\mathrm{kW/m^2}$, at a distance 22 cm from the lens on the other side is ....

Q 14. Two conducting cylinders of equal length but different radii are connected in series between two heat baths kept at temperatures $T_1 = 300$ K and $T_2 = 100$ K, as shown in the figure. The radius of the bigger cylinder is twice that of the smaller one and the thermal conductivities of the materials of the smaller and the larger cylinders are K_1 and K_2 respectively. If the temperature at the junction of the two cylinders in the steady state is 200 K, the $K_1/K_2 = \ldots\ldots.$



Paragraph Type

This section contains 2 paragraphs. Based on each paragraph, there are 2 questions. Each question has four options. Only one of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer. Answer to each question will be evaluated according to the following marking scheme:

1. Full Marks: (+3) If only the correct option is chosen.
2. Zero Marks: (0) If none of the options is chosen (i.e., the question is unanswered).
3. Negative Marks: (−1) In all other cases.

Paragraph for Questions 15-16

In electromagnetic theory, the electric and magnetic phenomena are related to each other. Therefore, the dimensions of electric and magnetic quantities must also be related to each other. In questions below, [E] and [B] stand for dimensions of electric and magnetic fields respectively, while $[\epsilon_0]$ and $[\mu_0]$ stand for dimensions of the permittivity and permeability of free space respectively. [L] and [T] are dimensions of length and time respectively. All the quantities are given in SI units. (2018)

Q 15. The relation between $[E]$ and $[B]$ is

(A) $[\mathrm{E}] = [\mathrm{B}][\mathrm{L}][\mathrm{T}]$
(B) $[\mathrm{E}] = [\mathrm{B}][\mathrm{L}]^{-1}[\mathrm{T}]$
(C) $[\mathrm{E}] = [\mathrm{B}][\mathrm{L}][\mathrm{T}]^{-1}$
(D) $[\mathrm{E}] = [\mathrm{B}][\mathrm{L}]^{-1}[\mathrm{T}]^{-1}$

Q 16. The relation between $[\epsilon_0]$ and $[\mu_0]$ is

(A) $[\mu_0] = [\epsilon_0][\mathrm{L}]^2[\mathrm{T}]^{-2}$
(B) $[\mu_0] = [\epsilon_0][\mathrm{L}]^{-2}[\mathrm{T}]^2$
(C) $[\mu_0] = [\epsilon_0]^{-1}[\mathrm{L}]^2[\mathrm{T}]^{-2}$
(D) $[\mu_0] = [\epsilon_0]^{-1}[\mathrm{L}]^{-2}[\mathrm{T}]^2$

Paragraph for Questions 17-18

If the measurement errors in all the independent quantities are known, then it is possible to determine the error in any dependent quantity. This is done by the use of series expansion and truncating the expansion at the first power of the error. For example, consider the relation $z = x/y$. If the errors in x, y and z are Δx, Δy and Δz, respectively, then

$$z \pm \Delta z = \frac{x \pm \Delta x}{y \pm \Delta y} = \frac{x}{y}\left(1 \pm \frac{\Delta x}{x}\right)\left(1 \pm \frac{\Delta y}{y}\right)^{-1}.$$

The series expansion for $\left(1 \pm \frac{\Delta y}{y}\right)^{-1}$, to first power in $\Delta y/y$, is $1 \mp (\Delta y/y)$. The relative errors in independent variables are always added. So the error in z will be

$$\Delta z = z\left(\frac{\Delta x}{x} + \frac{\Delta y}{y}\right).$$

The above derivation makes the assumption that $\Delta x/x \ll 1$, $\Delta y/y \ll 1$. Therefore, the higher powers of these quantities are neglected. (2018)

Q 17. Consider the ratio $r = \frac{1-a}{1+a}$ to be determined by measuring a dimensionless quantity a. If the error in the measurement of a is Δa ($\Delta a/a \ll 1$), then what is the error Δr in determining r?

(A) $\frac{\Delta a}{(1+a)^2}$ (B) $\frac{2\Delta a}{(1+a)^2}$ (C) $\frac{2\Delta a}{(1-a^2)}$ (D) $\frac{2a\Delta a}{(1-a^2)}$

Q 18. In an experiment the initial number of radioactive nuclei is 3000. It is found that 1000 ± 40 nuclei decayed in first 1.0 s. For $|x| \ll 1$, $\ln(1+x) = x$ up to first power in x. The error $\Delta\lambda$, in the determination of the decay constant λ, in s^{-1}, is

(A) 0.04 (B) 0.03 (C) 0.02 (D) 0.01

Answers

1. (B), (C)
2. (A), (C)
3. (A), (C)
4. (B), (D)
5. (A), (B), (D)
6. (B), (C), (D)
7. 2
8. 5
9. 0.75
10. 2.09
11. 1.5
12. 2
13. 130
14. 4
15. (C)
16. (D)
17. (B)
18. (C)

(Advanced) Paper 2

The physics part of the paper contains 18 questions of total marks 60. The questions are divided into three sections (1) multiple correct answers type (2) numerical type and (3) matrix matching type.

One or More Option(s) Correct

This section contains 6 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. For each question, choose the correct option(s) to answer the question. Answer to each question will be evaluated according to the following marking scheme:

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For example, if first, third and fourth are the ONLY three correct options for a question with second option

being an incorrect option; selecting only all the three correct options will result in $+4$ marks. Selecting only two of the three correct options (e.g. the first and fourth options), without selecting any incorrect option (second option in this case), will result in $+2$ marks. Selecting only one of the three correct options (either first or third or fourth option), without selecting any incorrect option (second option in this case), will result in $+1$ marks. Selecting any incorrect option(s) (second option in this case), with or without selection of any correct option(s) will result in -2 marks.

Q 1. Consider a thin square plate floating on a viscous liquid in large tank. The height h of the liquid in the tank is much less than the width of the tank. The floating plate is pulled horizontally with a constant velocity u_0. Which of the following statements is (are) true?

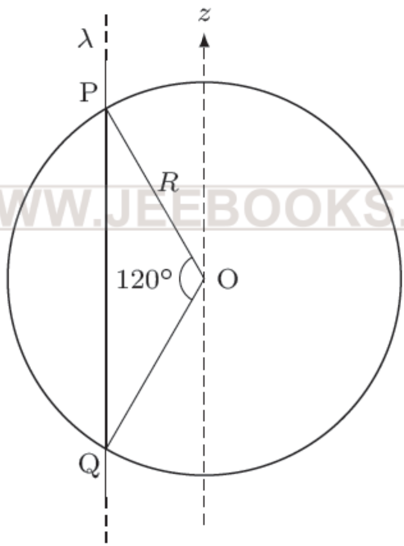
(A) The resistive force of liquid on the plate is inversely proportional to h.

(B) The resistive force of liquid on the plate is independent of the area of the plate.

(C) The tangential (shear) stress on the floor of the tank increases with u_0.

(D) The tangential (shear) stress on the plate varies linearly with the viscosity η of the liquid.

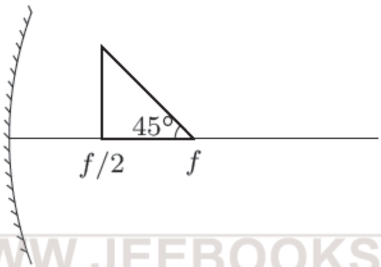
Q 2. An infinitely long thin non-conducting wire is parallel to the z-axis and carries a uniform line charge density λ. It pierces a thin non-conducting spherical shell of radius R in such a way that the arc PQ subtends an angle $120°$ at the centre O of the spherical shell, as shown in the figure. The permittivity of free space is ϵ_0. Which of the following statements is (are) true?



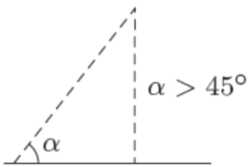
(A) The electric flux through the shell is $\sqrt{3}R\lambda/\epsilon_0$.
(B) The z-component of the electric field is zero at all the points on the surface of the shell.
(C) The electric flux through the shell is $\sqrt{2}R\lambda/\epsilon_0$.

(D) The electric field is normal to the surface of the shell at all points.

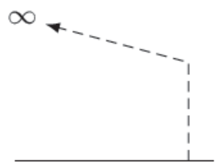
Q 3. A wire is bent in the shape of a right angled triangle and is placed in front of a concave mirror of focal length f, as shown in the figure. Which of the figures shown in the four options qualitatively represent(s) the shape of the image of the bent wire? (These figures are not to the scale.)



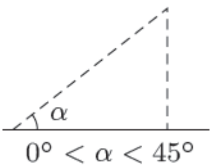
(A)



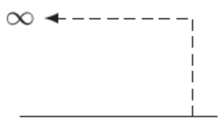
(B)



(C)



(D)



Q 4. In a radioactive decay chain, ${}^{232}_{90}\mathrm{Th}$ nucleus decays to ${}^{212}_{82}\mathrm{Pb}$ nucleus. Let N_α and N_β be the number of α and β^- particles, respectively, emitted in the decay process. Which of the following statements is (are) true?
(A) $N_\alpha = 5$ (B) $N_\alpha = 6$ (C) $N_\beta = 2$ (D) $N_\beta = 4$

Q 5. In an experiment to measure the speed of sound by a resonating air column, a tuning fork of frequency 500 Hz is used. The length of the air column is varied by changing the level of water in the resonance tube. Two successive resonances are heard at air columns of length 50.7 cm and 83.9 cm. Which of the following statements is (are) true?

(A) The speed of sound determined from this experiment is 332 m/s.

(B) The end correction in this experiment is 0.9 cm.

(C) The wavelength of the sound wave is 66.4 cm.

(D) The resonance at 50.7 cm corresponds to the fundamental harmonic.

Q 6. A particle of mass m is initially at rest at the origin. It is subjected to a force and starts moving along the x-axis. Its kinetic energy K changes with time as $\mathrm{d}K/\mathrm{d}t = \gamma t$, where γ is a positive constant of appropriate dimensions. Which of the following statements is (are) true?

(A) The force applied on the particle is constant.
(B) The speed of the particle is proportional to time.
(C) The distance of the particle from the origin increases linearly with time.
(D) The force is conservative.

Integer Type

This section contains 8 questions. The answer to each question is a numerical value. For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer. Answer to each question will be evaluated according to the following marking scheme:

1. Full Marks: (+3) If only the correct numerical value is entered as answer.
2. Zero Marks: (0) In all other cases.

Q 7. A steel wire of diameter 0.5 mm and Young's modulus 2×10^{11} N/m^2 carries a load of mass M. The length of the wire with the load is 1.0 m. A vernier scale with 10 divisions is attached to the end of this wire. Next to the steel wire is a reference wire to which a main scale, of least count 1.0 mm, is attached. The 10 divisions of the vernier scale correspond to 9 divisions of the main scale. Initially, the zero of vernier scale coincides with the zero of main scale. If the load on the steel wire is increased by 1.2 kg, the vernier scale division which coincides with a main scale division is .... [Take $g = 10$ m/s^2 and $\pi = 3.2$.]

Q 8. One mole of a monatomic ideal gas undergoes an adiabatic expansion in which its volume becomes eight times its initial value. If the initial temperature of the gas is 100 K and the universal gas constant $R = 8.0\ \mathrm{J\ mol^{-1}K^{-1}}$, the decrease in its internal energy, in *Joule*, is ....

Q 9. In a photoelectric experiment a parallel beam of monochromatic light with power of 200 W is incident on a perfectly absorbing cathode of work function 6.25 eV. The frequency of light is just above the threshold frequency so that the photoelectrons are emitted with negligible kinetic energy. Assume that the photoelectron emission efficiency is 100%. A potential difference of 500 V is applied between the cathode and the anode. All the emitted electrons are incident normally on the anode and are absorbed. The anode experiences a force $F = \mathrm{n} \times 10^{-4}$ N due to impact of the electrons. The value of n is .... [Mass of the electron $m_e = 9 \times 10^{-31}$ kg and $1.0\,\mathrm{eV} = 1.6 \times 10^{-19}$ J.]

Q 10. Consider a hydrogen-like ionized atom with atomic number Z with a single electron. In the emission spectrum of this atom, the photon emitted in the $n = 2$ to $n = 1$ transition has energy 74.8 eV higher than the photon emitted in the $n = 3$ to $n = 2$ transition. The ionization energy of the hydrogen atom is 13.6 eV. The value of Z is ....

Q 11. A moving coil galvanometer has 50 turns and each turn has an area 2×10^{-4} m^2. The magnetic field produced by the magnet inside the galvanometer is 0.02 T. The torsional constant of the suspension wire is 10^{-4} N m/rad. When a current flows through the galvanometer, full scale deflection occurs if the coil rotates by 0.2 rad. The resistance of the coil of the galvanometer is 50 Ω. This galvanometer is to be converted into an ammeter capable of measuring current in the range $0 - 1.0$ A. For this purpose, a shunt resistance is to be added in parallel to the galvanometer. The value of this shunt resistance, in *ohms*, is ....

Q 12. A particle, of mass 10^{-3} kg and charge 1.0 C, is initially at rest. At time $t = 0$, the particle comes under the influence of an electric field $\vec{E}(t) = E_0 \sin \omega t \, \hat{\imath}$, where $E_0 = 1.0$ N/C and $\omega = 10^3$ rad/s. Consider the effect of only the electric force on the particle. Then the maximum speed, in m/s, attained by the particle at subsequent times is ....

Q 13. A ball is projected from the ground at an angle of 45° with the horizontal surface. It reaches a maximum height of 120 m and returns to the ground. Upon hitting the ground for the first time, it loses half of its kinetic energy. Immediately after the bounce, the velocity of the ball makes an angle of 30° with the horizontal surface. The maximum height it reaches after the bounce, in *meters*, is ....

Q 14. A solid horizontal surface is covered with a thin layer of oil. A rectangular block of mass $m = 0.4$ kg is at rest on this surface. An impulse of $1.0\ \mathrm{N \cdot s}$ is applied to the block at time $t = 0$ so that it starts moving along the x-axis with a velocity $v(t) = v_0 e^{-t/\tau}$, where v_0 is a constant and $\tau = 4$ s. The displacement of the block, in *metres*, at $t = \tau$ is .... [Take $e^{-1} = 0.37$].

Matrix or Matching Type

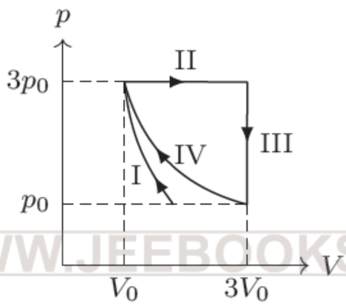
This section contains 4 questions. Each question has 2 matching lists: List-1 and List-II. Four options are given representing matching of elements from List-I and List-II. Only one of these four options corresponds to a correct matching. For each question, choose the option corresponding to the correct matching. For each question, marks will be awarded according to the following marking scheme:

1. Full Marks: (+3) If only the option corresponding to the correct matching is chosen.
2. Zero Marks: (0) If none of the options is chosen (i.e., the question is unanswered).
3. Negative Marks: (−1) In all other cases.

Q 15. In the *Column I* below, four different paths of a particle are given as a function of time. In these functions, α and β are positive constants of appropriate dimensions and $\alpha \neq \beta$. In each case, the force acting on the particle is either zero or conservative. In *Column II*, five physical quantities of the particle are mentioned: $\vec{p}$ is the linear momentum, $\vec{L}$ is the angular momentum about the origin, K is the kinetic energy, U is the potential energy and E is the total energy. Match each path in *Column I* with those quantities in *Column II*, which are *conserved for that path.*

Column I	Column II
(P) $\vec{r}(t) = \alpha t\,\hat{\imath} + \beta t\,\hat{\jmath}$	(1) $\vec{p}$
(Q) $\vec{r}(t) = \alpha \cos \omega t\,\hat{\imath} + \beta \sin \omega t\,\hat{\jmath}$	(2) $\vec{L}$
(R) $\vec{r}(t) = \alpha(\cos \omega t\,\hat{\imath} + \sin \omega t\,\hat{\jmath})$	(3) K
(S) $\vec{r}(t) = \alpha t\,\hat{\imath} + \frac{\beta}{2} t^2\,\hat{\jmath}$	(4) U
	(5) E

Q 16. One mole of a monatomic ideal gas undergoes four thermodynamics processes as shown schematically in p-V diagram below. Among these four processes, one is isobaric, one is isochoric, one is isothermal and one is adiabatic. Match the processes mentioned in *Column I* with the corresponding statements in *Column II.*



Column I	Column II
(P) In process I	(1) Work done by the gas is zero
(Q) In process II	(2) Temperature of the gas remained unchanged
(R) In process III	(3) No heat is exchanged between the gas and its surroundings
(S) In process IV	(4) Work done by the gas is $6p_0V_0$

Q 17. A planet of mass M, has two natural satellites with masses m_1 and m_2. The radii of their circular orbits are R_1 and R_2 respectively. Ignore the gravitational force between the satellites. Define v_1, L_1, K_1 and T_1 to be, respectively, the orbital speed, angular momentum, kinetic energy and time period of revolution of satellite 1; and v_2, L_2, K_2 and T_2 to be the corresponding quantities of satellite 2. Given $m_1/m_2 = 2$ and $R_1/R_2 = 1/4$, match the ratios in *Column-I* to the numbers in *Column-II*.

Column I	Column II
(P) v_1/v_2	(1) 1/8
(Q) L_1/L_2	(2) 1
(R) K_1/K_2	(3) 2
(S) T_1/T_2	(4) 8

Q 18. The electric field E is measured at a point $P(0, 0, d)$ generated due to various charge distributions and the dependence of E on d is found to be different for different charge distributions. *Column-I* contains different relations between E and d. *Column-II* describes different electric charge distributions, along with their locations. Match the functions in *Column-I* with the related charge distribution in *Column-II*.

Column I	Column II
(P) E is independent of d	(1) A point charge q at the origin.
(Q) $E \propto 1/d$	(2) A small dipole with point charge q at $(0, 0, l)$ and $-q$ at $(0, 0, -l)$. Take $2l \ll d$.
(R) $E \propto 1/d^2$	(3) An infinite line charge coincident with the x-axis, with uniform linear charge density λ.
(S) $E \propto 1/d^3$	(4) Two infinite wires carrying uniform linear charge density parallel to the x-axis. The one along $(y = 0, z = l)$ has a charge density $+\lambda$ and the one along $(y = 0, z = -l)$ has a charge density $-\lambda$. Take $2l \ll d$.
	(5) Infinite plane charge coincident with the x-y plane with uniform surface charge density.

Answers

1. (A), (C), (D)
2. (A), (B)
3. (D)
4. (A), (C)
5. (A), (B), (C)
6. (A), (B), (D)
7. 3
8. 900
9. 24
10. 3
11. 5.55
12. 2
13. 30
14. 6.3
15. P$\mapsto$(1,2,3,4,5), Q$\mapsto$(2,5), R$\mapsto$(2,3,4,5), S$\mapsto$(5)
16. P$\mapsto$(3), Q$\mapsto$(4), R$\mapsto$(1), S$\mapsto$(2)
17. P$\mapsto$(3), Q$\mapsto$(2), R$\mapsto$(4), S$\mapsto$(1)
18. P$\mapsto$(5), Q$\mapsto$(3), R$\mapsto$(1,4), S$\mapsto$(2)

IIT JEE 2017

IIT JEE 2017 was a two stage examination (i) JEE Mains by CBSE and (ii) JEE Advanced by JAB. There were two papers in JEE Advanced, namely (Advanced) Paper 1 and (Advanced) Paper 2. Each of the papers has three separate parts for physics, chemistry and mathematics.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

(Advanced) Paper 1

The physics part of the paper contains 18 questions of total marks 61. The questions are divided into three sections (1) multiple correct answers type (2) integer type and (3) paragraph or matching type.

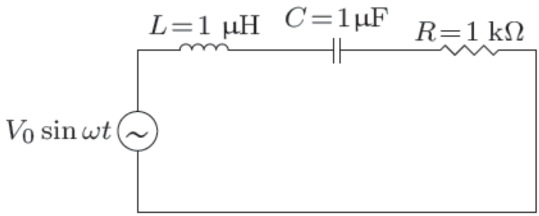
One or More Option(s) Correct

This section contains 7 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is (are) darkened
2. Partial Marks: (+1) For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened
3. Zero Marks: (0) If none of the bubbles is darkened
4. Negative Marks: (−2) In all other cases

For example, if (A), (C) and (D) are all the correct options for a question, darkening all these three will get +4 marks; darkening only (A) and (D) will get +2 marks; and darkening (A) and (B) will get −2 marks, as a wrong option is also darkened.

Q 1. In the circuit shown, $L = 1\ \mu\text{H}$, $C = 1\ \mu\text{F}$ and $R = 1\ \text{k}\Omega$. They are connected in series with an AC source $V = V_0 \sin\omega t$ as shown. Which of the following option(s) is(are) correct?



(A) At $\omega \approx 0$ the current flowing through the circuit becomes nearly zero.

(B) The frequency at which the current will be in phase with the voltage is independent of R.

(C) The current will be in phase with the voltage if $\omega = 10^4$ rad/s.

(D) At $\omega \gg 10^6$ rad/s, the circuit behaves like a capacitor.

Q 2. For an isosceles prism of angle A and refractive index μ, it is found that the angle of minimum deviation $\delta_m = A$. Which of the following option(s) is(are) correct?

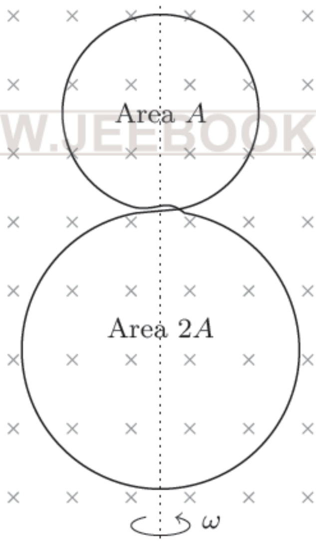
(A) For the angle of incidence $i_1 = A$, the ray inside the prism is parallel to the base of the prism.

(B) At minimum deviation, the incident angle i_1 and the refracting angle r_1 at the first refracting surface are related by $r_1 = (i_1/2)$.

(C) For this prism, the emergent ray at the second surface will be tangential to the surface when the angle of incidence at the first surface is $i_1 = \sin^{-1}\left[\sin A\sqrt{4\cos^2\frac{A}{2} - 1} - \cos A\right]$.

(D) For this prism, the refractive index μ and the angle of prism A are related as $A = \frac{1}{2}\cos^{-1}\left(\frac{\mu}{2}\right)$.

Q 3. A circular insulated copper wire loop is twisted to form two loops of area A and $2A$ as shown in the figure. *At the point of crossing the wires remain electrically insulated from each other.* The entire loop lies in the plane (of the paper). A uniform magnetic field $\vec{B}$ points into the plane of the paper. At $t = 0$, the loop starts rotating about the common diameter as axis with a constant angular velocity ω in the magnetic field. Which of the following option(s) is(are) correct?



(A) The *emf* induced in the loop is proportional to the sum of the areas of the two loops.

(B) The rate of change of the flux is maximum when the plane of the loops is perpendicular to plane of the paper.

(C) The net *emf* induced due to both the loops is proportional to $\cos \omega t$.

(D) The amplitude of the maximum net *emf* induced due to both the loops is equal to the amplitude of maximum *emf* induced in the smaller loop alone.

Q 4. A flat plate is moving normal to its plane through a gas under the action of a constant force F. The gas is kept at a very low pressure. The speed of the plate v is much less than the average speed u of the gas molecules. Which of the following option(s) is(are) true?

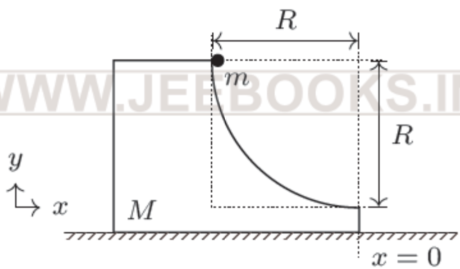
(A) At a later time the external force F balances the resistive force.

(B) The plate will continue to move with constant non-zero acceleration, at all times.

(C) The resistive force experienced by the plate is proportional to v.

(D) The pressure difference between the leading and trailing faces of the plate is proportional to uv.

Q 5. A block of mass M has a circular cut with a frictionless surface as shown. The block rests on the horizontal frictionless surface of a fixed table. Initially the right edge of the block is at $x = 0$, in a *co-ordinate system fixed to the table*. A point mass m is released from rest at the topmost point of the path as shown and it slides down. When the mass loses contact with the block, its position is x and the velocity is v. At that instant, which of the following option(s) is(are) correct?



(A) The velocity of the point mass m is $v = \sqrt{\frac{2gR}{1+m/M}}$.

(B) The x component of displacement of the centre of mass of the block M is $-\frac{mR}{M+m}$.

(C) The position of the point mass is $x = -\sqrt{2}\frac{mR}{M+m}$.

(D) The velocity of the block M is $V = -\frac{m}{M}\sqrt{2gR}$.

Q 6. A block M hangs vertically at the bottom end of a uniform rope of constant mass per unit length. The top end of the rope is attached to a fixed rigid support at O. A transverse wave pulse (Pulse 1) of wavelength λ_0 is produced at point O on the rope. The pulse takes time T_{OA} to reach point A. If the pulse of wavelength λ_0 is produced at point A (Pulse 2) without disturbing the position of M it takes time T_{AO} to reach point O. Which of the following option(s) is(are) correct?

(A) The time $T_{\mathrm{AO}} = T_{\mathrm{OA}}$.

(B) The wavelength of Pulse 1 becomes longer when it reaches point A.

(C) The velocity of any pulse along the rope is independent of its frequency and wavelength.

(D) The velocities of the two pulses (Pulse 1 and Pulse 2) are the same at the midpoint of rope.

Q 7. A human body has a surface area of approximately $1\,\mathrm{m}^2$. The normal body temperature is $10\,\mathrm{K}$ above the surrounding room temperature T_0. Take the room temperature to be $T_0 = 300$ K. For $T_0 = 300$ K, the value of $\sigma T_0^4 = 460\ \mathrm{W/m^2}$ (where σ is the Stefan-Boltzmann constant). Which of the following option(s) is(are) correct?

(A) If the body temperature rises significantly then the peak in the spectrum of electromagnetic radiation emitted by the body would shift to longer wavelengths.

(B) If the surrounding temperature reduces by a small amount $\Delta T_0 \ll T_0$, then to maintain the same body temperature the same (living) human being needs to radiate $\Delta W = 4\sigma T_0^3 \Delta T_0$ more energy per unit time.

(C) The amount of energy radiated by the body in 1 s is close to 60 Joules.

(D) Reducing the exposed surface area of the body (e.g., by curling up) allows human to maintain the same body temperature while reducing the energy lost by radiation.

Integer Type

This section contains 5 questions. The answer to each question is a single digit integer ranging from 0 to 9, both inclusive. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

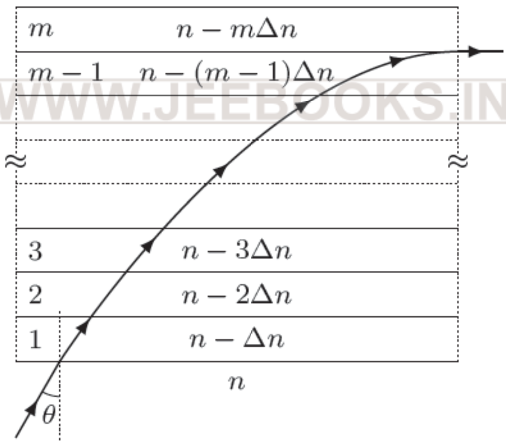
Q 8. An electron in a hydrogen atom undergoes a transition from an orbit with quantum number n_i to another with quantum number n_f. V_i and V_f are respectively the initial and final potential energies of the electron. If $\frac{V_i}{V_f} = 6.25$, then the *smallest possible* n_f is ....

Q 9. A drop of liquid of radius $R = 10^{-2}$ m having surface tension $S = \frac{0.1}{4\pi}$ N/m divides itself into K identical drops. In this process the total change in the surface energy $\Delta U = 10^{-3}$ J. If $K = 10^{\alpha}$ the the value of α is ....

Q 10. A stationary source emits sound of frequency $f_0 = 492\,\text{Hz}$. The sound is *reflected* by a large car *approaching* the source with a speed of 2 m/s. The reflected signal is received by the source and superposed with the original. What will be the beat frequency of the resulting signal in Hz? [Given that the speed of sound in air is 330 m/s and the car reflects the sound at the frequency *it* has received.].

Q 11. ^{131}I is an isotope of Iodine that β decays to an isotope of Xenon with a half-life of 8 days. A small amount of a serum labelled with ^{131}I is injected into the blood of a person. The activity of the amount of ^{131}I injected was 2.4×10^5 Becquerel (Bq). It is known that the injected serum will get distributed uniformly in the blood stream in less than half an hour. After 11.5 hours, 2.5 ml of blood is drawn from the person's body, and it gives an activity of 115 Bq. The total volume of blood in the person's body, in litres, is approximately .... [You may use $e^x \approx 1 + x$ for $|x| \ll 1$ and $\ln 2 \approx 0.7$].

Q 12. A monochromatic light is travelling in a medium of refractive index $n = 1.6$. It enters a stack of glass layers from the bottom side at an angle $\theta = 30°$. The interfaces of the glass layers are parallel to each other. The refractive indices of different glass layers are monotonically decreasing as $n_m = n - m\Delta n$, where n_m is the refractive index of the m^{th} slab and $\Delta n = 0.1$ (see the figure). The ray is refracted out parallel to the interface between the $(m-1)^{\text{th}}$ and m^{th} slabs from the right side of the stack. What is the value of m?



Paragraph Type

This section contains 6 questions based on two tables (each having 3 columns and 4 rows). Based on each table, there are three questions. Each question has four options (A), (B), (C), and (D). Only one of these four options is correct. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+3) If only the bubble corresponding to the correct option is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 13-15

A charged particle (electron or proton) is introduced at the origin ($x = 0, y = 0, z = 0$) with a given velocity $\vec{v}$. A uniform electric field $\vec{E}$ and a uniform magnetic field $\vec{B}$ exists everywhere. The velocity $\vec{v}$, electric field $\vec{E}$ and magnetic field $\vec{B}$ are given in columns 1, 2 and 3, respectively. The quantities E_0 and B_0 are positive in magnitude. (2017)

Column 1	Column 2 ($\vec{E}$)	Column 3 ($\vec{B}$)
(I) Electron, $\vec{v} = 2\frac{E_0}{B_0}\hat{x}$	(i) $E_0\hat{z}$	(P) $-B_0\hat{x}$
(II) Electron, $\vec{v} = \frac{E_0}{B_0}\hat{y}$	(ii) $-E_0\hat{y}$	(Q) $B_0\hat{x}$
(III) Proton, $\vec{v} = 0$	(iii) $-E_0\hat{x}$	(R) $B_0\hat{y}$
(IV) Proton, $\vec{v} = 2\frac{E_0}{B_0}\hat{x}$	(iv) $E_0\hat{x}$	(S) $B_0\hat{z}$

Q 13. In which case would the particle move in a straight line along the negative direction of y-axis (i.e., moves along $-\hat{y}$)?

(A) IV, ii, S (B) II, iii, Q

(C) III, ii, R (D) III, ii, P

Q 14. In which case will the particle move in a straight line with *constant* velocity?

(A) II, iii, S (B) III, iii, P

(C) IV, i, S (D) III, ii, R

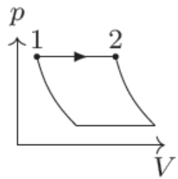
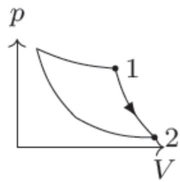
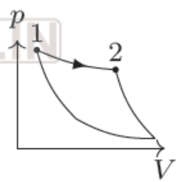
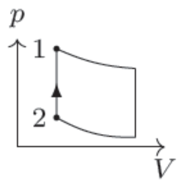
Q 15. In which case will the particle describe a helical path with axis along the positive z direction?

(A) II, ii, R (B) III, iii, P

(C) IV, i, S (D) IV, ii, R

Paragraph for Questions 16-18

An ideal gas is undergoing a cyclic thermodynamics process in different ways as shown in corresponding p-V diagrams in column 3 of the table. Consider only the path from state 1 to state 2. W denotes the corresponding work done on the system. The equations and plots in the table have standard notations used in thermodynamic processes. Here γ is the ratio of heat capacities at constant pressure and constant volume. The number of moles in the gas is n. (2017)

Column 1 ($W_{1\to 2}$)	Column 2	Column 3
(I) $\frac{p_2V_2-p_1V_1}{\gamma-1}$	(i) Isothermal	(P) 
(II) pV_1-pV_2	(ii) Isochoric	(Q) 
(III) 0	(iii) Isobaric	(R) 
(IV) $-nRT\ln\frac{V_2}{V_1}$	(iv) Adiabatic	(S) 

Q 16. Which one of the following options correctly represents a thermodynamic process that is used as a correction in the determination of the speed of sound in an ideal gas?

(A) IV, ii, R (B) I, ii, Q

(C) I, iv, Q (D) III, iv, R

Q 17. Which of the following options is the only correct representation of a process in which $\Delta U = \Delta Q - p\Delta V$?

(A) II, iii, S (B) II, iii, P

(C) III, iii, P (D) II, iv, R

Q 18. Which of the following options is the correct combination?

(A) II, iv, P (B) III, ii, S

(C) II, iv, R (D) IV, ii, S

Answers

1. (A), (B)
2. (A), (B), (C)
3. (B), (D)
4. (A), (C), (D)
5. (A), (B)
6. (A), (C)
7. (D)
8. 5
9. 6
10. 6
11. 5
12. 8
13. (C)
14. (A)
15. (C)
16. (C)
17. (B)
18. (B)

(Advanced) Paper 2

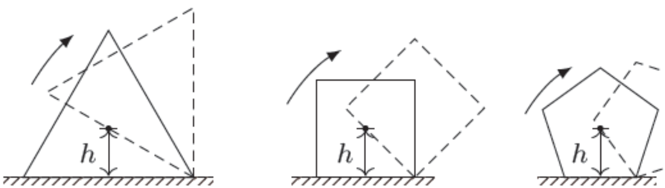
The physics part of the paper contains 18 questions of total marks 61. The questions are divided into three sections (1) single correct answer type (2) multiple correct answers type and (3) paragraph type.

One Option Correct

This section contains 7 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. For each question, marks will be awarded in one of the following categories:

1. Full Marks: +3 If only the bubble corresponding to the correct option is darkened
2. Zero Marks: 0 If none of the bubbles is darkened
3. Negative Marks: −1 In all other cases

Q 1. Consider regular polygons with number of sides $n = 3, 4, 5, \ldots$ as shown in the figure. The center of mass of all the polygons is at height h from the ground. They roll on a horizontal surface about the leading vertex without slipping and sliding as depicted. The maximum increase in height of the locus of the center of mass for each polygon is Δ. Then Δ depends on n and h as



(A) $\Delta = h\sin^2\left(\frac{\pi}{n}\right)$ (B) $\Delta = h\sin\left(\frac{2\pi}{n}\right)$

(C) $\Delta = h\tan^2\left(\frac{\pi}{2n}\right)$ (D) $\Delta = h\left(1/\cos\left(\frac{\pi}{n}\right) - 1\right)$

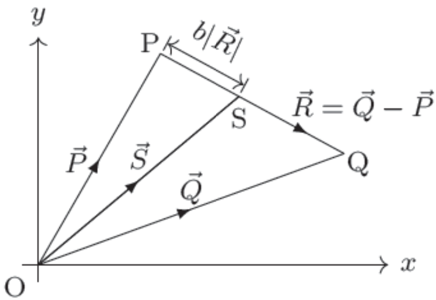
Q 2. Consider an expanding sphere of instantaneous radius r whose total mass remains constant. The expansion is such that the *instantaneous* density ρ remains uniform throughout the volume. The rate of fractional change in density $\left(\frac{1}{\rho}\frac{\mathrm{d}\rho}{\mathrm{d}t}\right)$ is constant. The velocity v of any point on the surface of the expanding sphere is proportional to

(A) r (B) $1/r$ (C) r^3 (D) $r^{2/3}$

Q 3. A photoelectric material having work-function ϕ_0 is illuminated with light of wavelength $\lambda\,(\lambda < hc/\phi_0)$. The fastest photoelectron has a de Broglie wavelength λ_d. A change in wavelength of the incident light by $\Delta\lambda$ results in a change $\Delta\lambda_d$ in λ_d. Then the ratio $\Delta\lambda_d/\Delta\lambda$ is proportional to

(A) λ_d^2/λ^2 (B) λ_d/λ (C) λ_d^3/λ (D) λ_d^3/λ^2

Q 4. The vectors $\vec{P}$, $\vec{Q}$ and $\vec{R}$ are shown in the figure. Let S be any point on the vector $\vec{R}$. The distance between the points P and S is $b|\vec{R}|$. The general relation among vectors $\vec{P}$, $\vec{Q}$ and $\vec{S}$ is



(A) $\vec{S} = (1 - b^2)\vec{P} + b\vec{Q}$ (B) $\vec{S} = (b - 1)\vec{P} + b\vec{Q}$

(C) $\vec{S} = (1 - b)\vec{P} + b\vec{Q}$ (D) $\vec{S} = (1 - b)\vec{P} + b^2\vec{Q}$

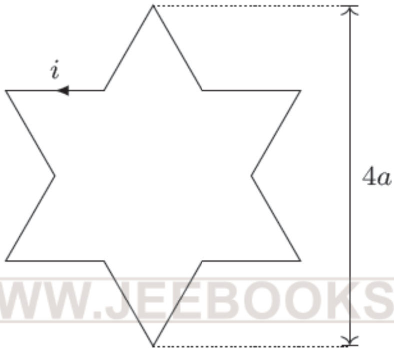
Q 5. A person measures the depth of a well by measuring the time interval between dropping a stone and receiving the sound of impact with the bottom of the well. The error in his measurement of time is $\delta T = 0.01$ s and he measures the depth of the well to be $L = 20$ m. Take the acceleration due to gravity $g = 10$ m/s^2 and the velocity of sound is 300 m/s. Then the fractional error in the measurement, $\delta L/L$, is closest to

(A) 1% (B) 5% (C) 3% (D) 0.2%

Q 6. A rocket is launched normal to the surface of the earth, away from the sun, along the line joining the sun and the earth. The sun is 3×10^5 times heavier than the earth and is at a distance 2.5×10^4 times larger than the radius of the earth. The escape velocity from the earth's gravitational field is $v_e = 11.2\,\text{km/s}$. The minimum initial velocity (v_s) required for the rocket to be able to leave the *sun-earth system* is closest to [Ignore the rotation and revolution of the earth and the presence of any other planet.]

(A) $v_s = 72\text{ km/s}$ (B) $v_s = 22\text{ km/s}$
(C) $v_s = 42\text{ km/s}$ (D) $v_s = 62\text{ km/s}$

Q 7. A symmetric star shaped conducting wire loop is carrying a steady current i as shown in the figure. The distance between the diametrically opposite vertices of the star is $4a$. The magnitude of the magnetic field at the center of the loop is



(A) $\frac{\mu_0 i}{4\pi a} 6\left(\sqrt{3}-1\right)$ (B) $\frac{\mu_0 i}{4\pi a} 6\left(\sqrt{3}+1\right)$
(C) $\frac{\mu_0 i}{4\pi a} 3\left(\sqrt{3}-1\right)$ (D) $\frac{\mu_0 i}{4\pi a} 3\left(2-\sqrt{3}\right)$

One or More Option(s) Correct

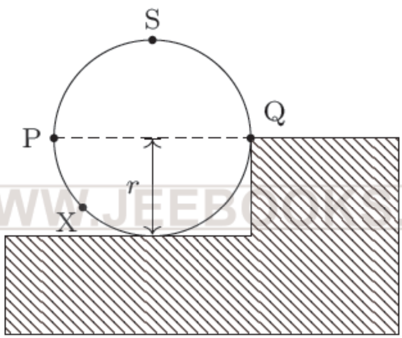
This section contains 7 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened

2. Partial Marks: (+1) For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened
3. Zero Marks: (0) If none of the bubbles is darkened
4. Negative Marks: (−2) In all other cases

For example, if (A), (C) and (D) are all the correct options for a question, darkening all these three will get +4 marks; darkening only (A) and (D) will get +2 marks; and darkening (A) and (B) will get −2 marks, as a wrong option is also darkened.

Q 8. A wheel of radius r and mass m is placed at the bottom of a fixed step of height r as shown in the figure. A constant force is continuously applied on the surface of the wheel so that it just climbs the step without slipping. Consider the torque τ about an axis normal to the plane of the paper passing through the point Q. Which of the following option(s) is(are) correct?



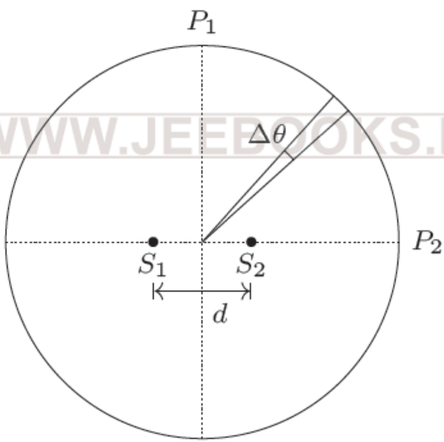
(A) If the force is applied normal to the circumference at point P then τ is zero.

(B) If the force is applied tangentially at point S then $\tau \neq 0$ but the wheel never climbs the step.

(C) If the force is applied at point P tangentially then τ decreases continuously as the wheel climbs.

(D) If the force is applied normal to the circumference at point X then τ is constant.

Q 9. Two coherent monochromatic point sources S_1 and S_2 of wavelength $\lambda = 600$ nm are placed symmetrically on either side of the centre of the circle as shown. The sources are separated by a distance $d = 1.8$ mm. This arrangement produces interference fringes visible as alternate bright and dark spots on the circumference of the circle. The angular separation between two consecutive bright spots is $\Delta\theta$. Which of the following option(s) is(are) correct?



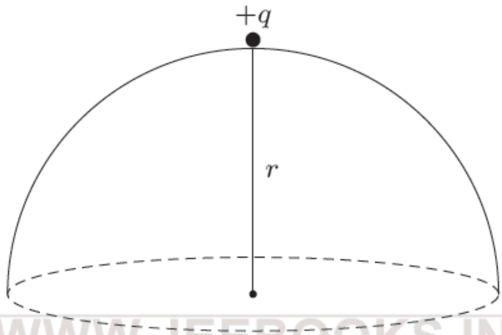
(A) The angular separation between two consecutive bright spots decreases as we move from P_1 to P_2 along the first quadrant.

(B) A dark spot will be formed at the point P_2.

(C) The total number of fringes produced between P_1 and P_2 in the first quadrant is close to 3000.

(D) At P_2 the order of the fringe will be maximum.

Q 10. A point charge $+q$ is placed just outside an imaginary hemispherical surface of radius r as shown in the figure. Which of the following statement(s) is(are) correct?



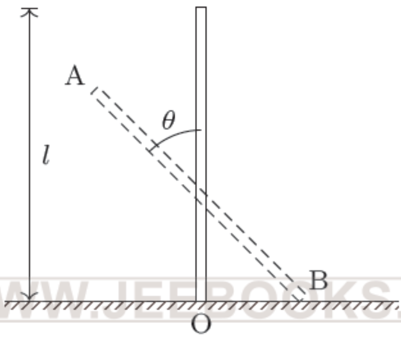
(A) The electric flux passing through the *curved* surface of the hemisphere is $-\frac{q}{2\epsilon_0}\left(1-\frac{1}{\sqrt{2}}\right)$.

(B) The component of the electric field normal to the flat surface is constant over the surface.

(C) Total electric flux through the curved and the flat surfaces is q/ϵ_0.

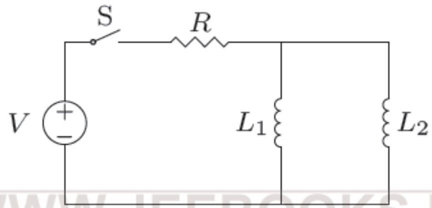
(D) The circumference of the flat surface is an equipotential.

Q 11. A rigid uniform bar AB of length l is slipping from its vertical position on a frictionless floor (as shown in the figure). At some instant of time, the angle made by the bar with the vertical is θ. Which of the following statement(s) about its motion is(are) correct?



(A) Instantaneous torque about the point in contact with the floor is proportional to $\sin\theta$.
(B) The trajectory of the point A is a parabola.
(C) The midpoint of the bar will fall vertically downward.
(D) When the bar makes an angle θ with the vertical, the displacement of its midpoint from the initial position is proportional to $(1 - \cos\theta)$.

Q 12. A source of constant voltage V is connected to a resistance R and two identical inductors L_1 and L_2 through a switch S as shown. There is no mutual inductance between the two inductors. The switch S is initially open. At $t = 0$, the switch is closed and current begins to flow. Which of the following option(s) is(are) correct?



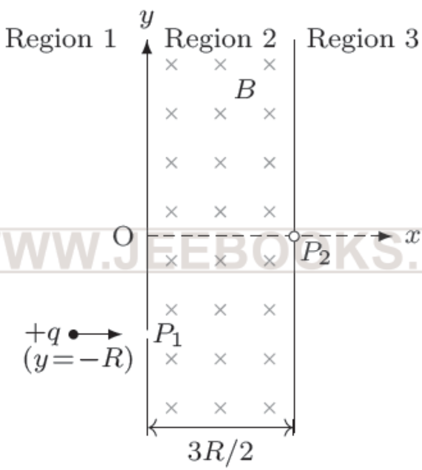
(A) After a long time, the current through L_1 will be $\frac{V}{R}\frac{L_2}{L_1+L_2}$.

(B) After a long time, the current through L_2 will be $\frac{V}{R}\frac{L_1}{L_1+L_2}$.

(C) The ratio of the currents through L_1 and L_2 is fixed at all times ($t > 0$).

(D) At $t = 0$, the current through the resistance R is V/R.

Q 13. A uniform magnetic field B exists in the region between $x = 0$ and $x = 3R/2$ (region 2 in the figure) pointing normally into the plane of the paper. A particle with charge $+q$ and momentum p directed along x-axis enters region 2 from region 1 at point $P_1(y = -R)$. Which of the following option(s) is(are) correct?



(A) When the particle re-enters region 1 through the longest possible path in region 2, the magnitude of the change in its linear momentum between point P_1 and the farthest point from y-axis is $p/\sqrt{2}$.

(B) For $B = \frac{8}{13}\frac{p}{qR}$, the particle will enter region 3 through the point P_2 on x-axis.

(C) For $B > \frac{2}{3}\frac{p}{qR}$, the particle will re-enter region 1.

(D) For a fixed B, particle of same charge q and same velocity v, the distance between the point P_1 and the point of re-entry into region 1 is inversely proportional to the mass of the particle.

Q 14. The instantaneous voltages at three terminals marked X, Y and Z are given by

$$V_X = V_0 \sin \omega t,$$
$$V_Y = V_0 \sin(\omega t + 2\pi/3), \text{ and}$$
$$V_Z = V_0 \sin(\omega t + 4\pi/3).$$

An ideal voltmeter is configured to read *rms* value of the potential difference between its terminals. It is connected between point X and Y and then between Y and Z. The reading(s) of the voltmeter will be

(A) $V_{\mathrm{YZ}}^{\mathrm{rms}} = V_0\sqrt{1/2}$.

(B) $V_{\mathrm{XY}}^{\mathrm{rms}} = V_0\sqrt{3/2}$.

(C) independent of the choice of the two terminals.

(D) $V_{\mathrm{XY}}^{\mathrm{rms}} = 0$.

Paragraph Type

This section contains 4 questions based on two paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+3) If only the bubble corresponding to the correct option is darkened
2. Zero Marks: (0) In all other cases

Paragraph for Questions 15-16

Consider a simple RC circuit shown in figure 1.

Process 1: In the circuit the switch S is closed at $t = 0$ and the capacitor is fully charged to voltage V_0 (i.e., charging continues for time $T \gg RC$). In the process some dissipation (E_D) occurs across the resistance R. The amount of energy finally stored in the fully charged capacitor is E_C.

Process 2: In a different process the voltage is first set to $V_0/3$ and maintained for a charging time $T \gg RC$. Then the voltage is raised to $2V_0/3$ without discharging the capacitor and again maintained for a time $T \gg RC$. The process is repeated one more time by raising the voltage to V_0 and the capacitor is charged to the same final voltage V_0 as in process 1.

These two processes are depicted in figure 2.

(2017)

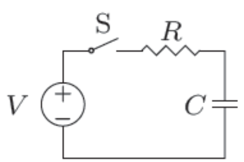


Figure 1

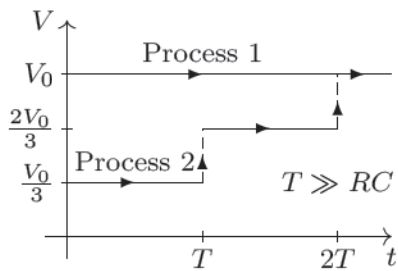


Figure 2

Q 15. In process 1, the energy stored in the capacitor E_C and heat dissipated across resistance E_D are related by

(A) $E_C = E_D \ln 2$ (B) $E_C = E_D$
(C) $E_C = 2E_D$ (D) $E_C = E_D/2$

Q 16. In process 2, total energy dissipated across the resistance E_D is

(A) $E_D = \frac{1}{6}CV_0^2$ (B) $E_D = \frac{3}{2}CV_0^2$

(C) $E_D = 3CV_0^2$ (D) $E_D = \frac{1}{2}CV_0^2$

Paragraph for Questions 17-18

One twirls a circular ring (of mass M and radius R) near the tip of one's finger as shown in figure 1. In the process the finger never loses contact with the inner rim of the ring. The finger traces out the surface of a cone, shown by the dotted line. The radius of the path traced out by the point where the ring and the finger is in contact is r. The finger rotates with an angular velocity ω_0. The rotating ring *rolls without slipping* on the outside of a smaller circle described by the point where the ring and the finger is in contact (figure 2). The coefficient of friction between the ring and the finger is μ and the acceleration due to gravity is g. (2017)

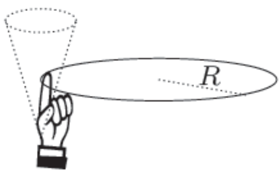


Figure 1

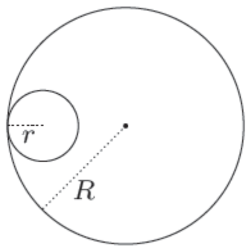


Figure 2

Q 17. The total kinetic energy of the ring is

(A) $M\omega_0^2(R-r)^2$ (B) $\frac{1}{2}M\omega_0^2(R-r)^2$

(C) $M\omega_0^2R^2$ (D) $\frac{3}{2}M\omega_0^2(R-r)^2$

Q 18. The minimum value of ω_0 below which the ring will drop down is

(A) $\sqrt{\frac{g}{2\mu(R-r)}}$ (B) $\sqrt{\frac{3g}{2\mu(R-r)}}$

(C) $\sqrt{\frac{g}{\mu(R-r)}}$ (D) $\sqrt{\frac{2g}{\mu(R-r)}}$

Answers

1. (D)
2. (A)
3. (D)
4. (C)
5. (A)
6. (C)
7. (A)
8. (A) also see solution.
9. (C), (D)
10. (A), (D)
11. (A), (C), (D)
12. (A), (B), (C)
13. (B), (C)
14. (B), (C)
15. (B)
16. (A)
17. None (see solution)
18. (C)

IIT JEE 2016

IIT JEE 2016 was a two stage examination (i) JEE Mains by CBSE and (ii) JEE Advanced by JAB. There were two papers in JEE Advanced namely, (Advanced) Paper 1 and (Advanced) Paper 2. Each of the papers has three separate parts for physics, chemistry and mathematics.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

(Advanced) Paper 1

The physics part of the paper contains 18 questions of total marks 62. The questions are divided into three sections (1) single correct answer type (2) multiple correct answers type and (3) integer type.

One Option Correct

This section contains 5 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. For each question, marks will be awarded in one of the following categories:

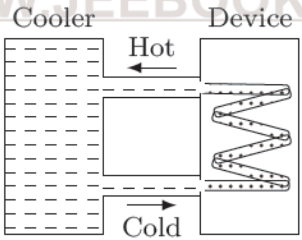
1. Full Marks: +3 If only the bubble corresponding to the correct option is darkened
2. Zero Marks: 0 If none of the bubbles is darkened
3. Negative Marks: −1 In all other cases

Q 1. A uniform wooden stick of mass 1.6 kg and length l rests in an inclined manner on a smooth, vertical wall of height $h\,(< l)$ such that a small portion of the stick extends beyond the wall. The reaction force of the wall on the stick is perpendicular to the stick. The stick makes an angle of 30° with the wall and the bottom of the stick is on a rough floor. The reaction of the wall on the stick is equal in magnitude to the reaction of the floor on the stick. The ratio h/l and the frictional force f at the bottom of the stick are $[\,g = 10\ \mathrm{m/s^2}\,]$

(A) $\frac{h}{l} = \frac{\sqrt{3}}{16},\ f = \frac{16\sqrt{3}}{3}$ N (B) $\frac{h}{l} = \frac{3}{16},\ f = \frac{16\sqrt{3}}{3}$ N

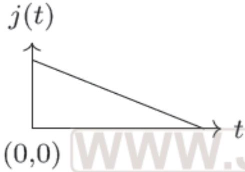
(C) $\frac{h}{l} = \frac{3\sqrt{3}}{16},\ f = \frac{8\sqrt{3}}{3}$ N (D) $\frac{h}{l} = \frac{3\sqrt{3}}{16},\ f = \frac{16\sqrt{3}}{3}$ N

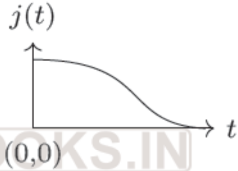
Q 2. A water cooler of storage capacity 120 litres can cool water at a constant rate of P watts. In a closed circulation system (as shown schematically in the figure), the water from the cooler is used to cool an external device that generates constantly 3 kW of heat (thermal load). The temperature of water fed into the device cannot exceed 30 °C and the entire stored 120 litres of water is initially cooled to 10 °C. The entire system is thermally insulated. The minimum value of P (in watts) for which the device can be operated for 3 hours is [Specific heat of water is 4.2 kJ kg^{-1}K^{-1} and the density of water is 1000 kg/m^3.]

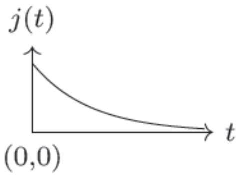


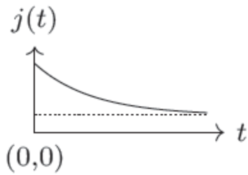
(A) 1600 (B) 2067 (C) 2533 (D) 3933

Q 3. An infinite line charge of uniform electric charge density λ lies along the axis of an electrically conducting infinite cylindrical shell of radius R. At time $t = 0$, the space inside the cylinder is filled with a material of permittivity ϵ and electrical conductivity σ. The electrical conduction in the material follows Ohm's law. Which one of the following graphs best describes the subsequent variation of the magnitude of the current density $j(t)$ at any point in the material?

(A) 

(B) 

(C) 

(D) 

Q 4. In a historical experiment to determine Planck's constant, a metal surface was irradiated with light of different wavelengths. The emitted photoelectron energies were measured by applying a stopping potential. The relevant data for the wavelength (λ) of incident light and the corresponding stopping potential (V_0) are given below:

λ (μm)	V_0 (Volt)
0.3	2.0
0.4	1.0
0.5	0.4

Given that $c = 3 \times 10^8$ m/s and $e = 1.6 \times 10^{-19}$ C, Planck's constant (in units of J-s) found from such an experiment is

(A) 6.0×10^{-34} (B) 6.4×10^{-34}
(C) 6.6×10^{-34} (D) 6.8×10^{-34}

One or More Option(s) Correct

This section contains 8 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Partial Marks: (+1) For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened
3. Zero Marks: (0) If none of the bubbles is darkened
4. Negative Marks: (−2) In all other cases

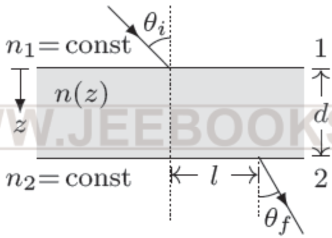
For example, if (A), (C) and (D) are all the correct options for a question, darkening all these three will get +4 marks; darkening only (A) and (D) will get +2 marks; and darkening (A) and (B) will get −2 marks, as a wrong option is also darkened.

Q 5. A length-scale (l) depends on the permittivity (ϵ) of a dielectric material, Boltzmann constant (k_B), the absolute temperature (T), the number per unit volume (n) of certain charged particles, and the charge (q) carried by each of the particles. Which of the following expression(s) for l is(are) dimensionally correct?

(A) $l = \sqrt{\frac{nq^2}{\epsilon k_B T}}$ (B) $l = \sqrt{\frac{\epsilon k_B T}{nq^2}}$

(C) $l = \sqrt{\frac{q^2}{\epsilon n^{2/3} k_B T}}$ (D) $l = \sqrt{\frac{q^2}{\epsilon n^{1/3} k_B T}}$

Q 6. A transparent slab of thickness d has a refractive index $n(z)$ that increases with z. Here z is the vertical distance inside the slab, measured from the top. The slab is placed between two media with uniform refractive indices n_1 and $n_2\,(> n_1)$, as shown in the figure. A ray of light is incident with angle θ_i from medium 1 and emerges in the medium 2 with refraction angle θ_f with a lateral displacement l. Which of the following statement(s) is(are) true?



(A) $n_1 \sin\theta_i = n_2 \sin\theta_f$
(B) $n_1 \sin\theta_i = (n_2 - n_1)\sin\theta_f$
(C) l is independent of n_2
(D) l is dependent of $n(z)$

Q 7. The position vector $\vec{r}$ of a particle of mass m is given by the following equation

$$\vec{r}(t) = \alpha t^3\,\hat{\imath} + \beta t^2\,\hat{\jmath},$$

where $\alpha = 10/3\ \mathrm{m/s^3}$, $\beta = 5\ \mathrm{m/s^2}$ and $m = 0.1$ kg. At $t = 1$ s, which of the following statement(s) is(are) true about the particle?

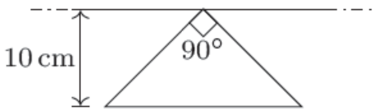
(A) The velocity $\vec{v}$ is given by $\vec{v} = (10\,\hat{\imath} + 10\,\hat{\jmath})$ m/s.

(B) The angular momentum $\vec{L}$ with respect to the origin is given by $\vec{L} = -5/3\,\hat{\mathrm{k}}$ N-m-s.

(C) The force $\vec{F}$ is given by $\vec{F} = (\hat{\imath} + 2\hat{\jmath})$ N.

(D) The torque $\vec{\tau}$ with respect to the origin is given by $\vec{\tau} = -20/3\,\hat{\mathrm{k}}$ N-m.

Q 8. A conducting loop in the shape of a right angled isosceles triangle of height 10 cm is kept such that the 90° vertex is very close to an infinitely long conducting wire (see the figure). The wire is electrically insulated from the loop. The hypotenuse of the triangle is parallel to the wire. The current in the triangular loop is in counterclockwise direction and increased at a constant rate of 10 A/s. Which of the following statement(s) is(are) true?



(A) The magnitude of induced *emf* in the wire is μ_0/π volt.

(B) If the loop is rotated at a constant angular speed about the wire, an additional *emf* of μ_0/π volt is induced in the wire.

(C) The induced current in the wire is in opposite direction to the current along the hypotenuse.

(D) There is a repulsive force between the wire and the loop.

Q 9. A plano-convex lens is made of material of refractive index n. When a small object is placed 30 cm away in front of the curved surface of the lens, an image of double the size of the object is produced. Due to reflection from the convex surface of the lens, another faint image is observed at a distance of 10 cm away from the lens. Which of the following statement(s) is(are) true?

(A) The refractive index of the lens is 2.5.
(B) The radius of curvature of the convex surface is 45 cm.
(C) The faint image is erect and real.
(D) The focal length of the lens is 20 cm.

Q 10. An incandescent bulb has a thin filament of tungsten that is heated to high temperature by passing an electric current. The hot filament emits black-body radiation. The filament is observed to break up at random locations after a sufficiently long time of operation due to non-uniform evaporation of tungsten from the filament. If the bulb is powered at constant voltage, which of the following statement(s) is(are) true?

(A) The temperature distribution over the filament is uniform.

(B) The resistance over small sections of the filament decreases with time.

(C) The filament emits more light at higher band of frequencies before it breaks up.

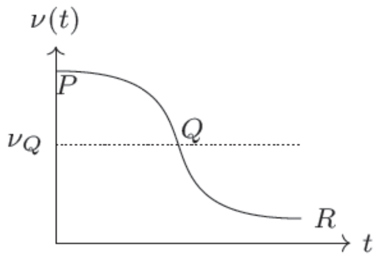
(D) The filament consumes less electrical power towards the end of the life of the bulb.

Q 11. Two loudspeakers M and N are located 20 m apart and emit sound at frequencies 118 Hz and 121 Hz, respectively. A car is initially at a point P, 1800 m away from the midpoint Q of the line MN and moves towards Q constantly at 60 km/hr along the perpendicular bisector of MN. It crosses Q and eventually reaches a point R, 1800 m away from Q. Let $\nu(t)$ represent the beat frequency measured by a person sitting in the car at time t. Let ν_P, ν_Q and ν_R be the beat frequencies measured at locations P, Q and R, respectively. The speed of sound in air is 330 m/s. Which of the following statement(s) is(are) true regarding the sound heard by the person?

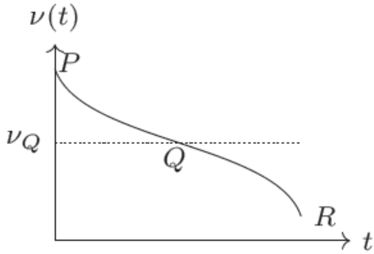
(A) $\nu_P + \nu_R = 2\nu_Q$.

(B) The rate of change in beat frequency is maximum when the car passes through Q.

(C) The plot below represents schematically the variation of beat frequency with time.



(D) The plot below represents schematically the variation of beat frequency with time.


$\nu(t)$
P
ν_Q
Q
R
t

Q 12. Highly excited states for hydrogen-like atoms (also called Rydberg states) with nuclear charge Ze are defined by their principal quantum number n, where $n \gg 1$. Which of the following statement(s) is(are) true?

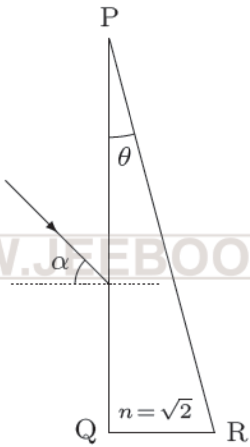
(A) Relative change in the radii of two consecutive orbitals does not depend on Z.

(B) Relative change in the radii of two consecutive orbitals varies as $1/n$.

(C) Relative change in the energy of two consecutive orbitals varies as $1/n^3$.

(D) Relative change in the angular momenta of two consecutive orbitals varies as $1/n$.

Q 13. A parallel beam of light is incident from air at an angle α on the side PQ of a right angled triangular prism of refractive index $n = \sqrt{2}$. Light undergoes total internal reflection in the prism at the face PR when α has a minimum value of 45°. The angle θ of the prism is



(A) 15° (B) 22.5° (C) 30° (D) 45°

Integer Type

This section contains 5 questions. The answer to each question is a single digit integer ranging from 0 to 9, both inclusive. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

Q 14. A metal is heated in a furnace where a sensor is kept above the metal surface to read the power radiated (P) by the metal. The sensor has a scale that displays $\log_2(P/P_0)$, where P_0 is a constant. When the metal surface is at a temperature of 487 °C, the sensor shows a value of 1. Assume that the emissivity of the metallic surface remains constant. What is the value displayed by the sensor when the temperature of the metal surface is raised to 2767 °C?

Q 15. The isotope $^{12}_{5}\mathrm{B}$ having a mass 12.014 u undergoes β-decay to $^{12}_{6}\mathrm{C}$. $^{12}_{6}\mathrm{C}$ has an excited state of the nucleus ($^{12}_{6}\mathrm{C}^*$) at 4.041 MeV above its ground state. If $^{12}_{5}\mathrm{B}$ decays to $^{12}_{6}\mathrm{C}^*$, the maximum kinetic energy of the β-particle in units of MeV is .... [1 u = 931.5 MeV/c^2, where c is the speed of light in vacuum.]

Q 16. A hydrogen atom in its ground state is irradiated by light of wavelength 970 Å. Taking $hc = 1.237 \times 10^{-6}$ eV m and the ground state energy of hydrogen atom as -13.6 eV, the number of lines present in the emission spectrum is ....

Q 17. Consider two solid spheres P and Q each of density $8\,\mathrm{g/cm^3}$ and diameters 1 cm and 0.5 cm, respectively. Sphere P is dropped into a liquid of density $0.8\,\mathrm{g/cm^3}$ and viscosity $\eta = 3$ poiseulles. Sphere Q is dropped into a liquid of density $1.6\,\mathrm{g/cm^3}$ and viscosity $\eta = 2$ poiseulles. The ratio of the terminal velocities of P and Q is ....

Q 18. Two inductors L_1 (inductance 1 mH, internal resistance 3 Ω) and L_2 (inductance 2 mH, internal resistance 4 Ω), and a resistor R (resistance 12 Ω) are all connected in parallel across a 5 V battery. The circuit is switched on at time $t = 0$. The ratio of the maximum to the minimum current ($I_{\text{max}}/I_{\text{min}}$) drawn from the battery is ....

Answers

1. D
2. B
3. C
4. B
5. B, D
6. A, C, D
7. A, B, D
8. A, D
9. A, D
10. C, D
11. A, B, C
12. A, B, D
13. A
14. 9
15. 9
16. 6
17. 3
18. 8

(Advanced) Paper 2

The physics part of the paper contains 18 questions of total marks 62. The questions are divided into three sections (1) single correct answer type (2) multiple correct answers type and (3) paragraph type.

One Option Correct

This section contains 6 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. For each question, marks will be awarded in one of the following categories:

1. Full Marks: +3 If only the bubble corresponding to the correct option is darkened
2. Zero Marks: 0 If none of the bubbles is darkened
3. Negative Marks: −1 In all other cases

Q 1. The electrostatic energy of Z protons uniformly distributed throughout a spherical nucleus of radius R is given by

$$E = \frac{3}{5}\frac{Z(Z-1)e^2}{4\pi\epsilon_0 R}.$$

The measured masses of the neutron, ${}^1_1\mathrm{H}$, ${}^{15}_{7}\mathrm{N}$, ${}^{15}_{8}\mathrm{O}$ are 1.008665 u, 1.007825 u, 15.000109 u and 15.003065 u, respectively. Given that the radii of both the ${}^{15}_{7}\mathrm{N}$ and ${}^{15}_{8}\mathrm{O}$ nuclei are same, $1\ \mathrm{u} = 931.5\ \mathrm{MeV/c^2}$ (c is the speed of light) and $e^2/(4\pi\epsilon_0) = 1.44$ MeV-fm. Assuming that the difference between the binding energies of ${}^{15}_{7}\mathrm{N}$ and ${}^{15}_{8}\mathrm{O}$ is purely due to the electrostatic energy, the radius of either of the nuclei is $[1\ \mathrm{fm} = 10^{-15}\ \mathrm{m}]$

(A) 2.85 fm (B) 3.03 fm (C) 3.42 fm (D) 3.80 fm

Q 2. An accident in a nuclear laboratory resulted in deposition of a certain amount of radioactive material of half life 18 days inside the laboratory. Tests revealed that the radiation was 64 times more than the permissible level required for safe operation of the laboratory. What is the minimum number of days after which the laboratory can be considered safe for use?
(A) 64 (B) 90 (C) 108 (D) 120

Q 3. A gas is enclosed in a cylinder with a movable frictionless piston. Its initial thermodynamic state at pressure $p_i = 10^5$ Pa and volume $V_i = 10^{-3}$ m^3 changes to a final state $p_f = (1/32) \times 10^5$ Pa and $V_f = 8 \times 10^{-3}$ m^3 in an adiabatic quasi-static process, such that $p^3V^5 =$ constant. Consider another thermodynamic process that brings the system from the same initial state to the same final state in two steps: an isobaric expansion at p_i followed by an isochoric (isovolumetric) process at volume V_f. The amount of heat supplied to the system in the two-step process is approximately

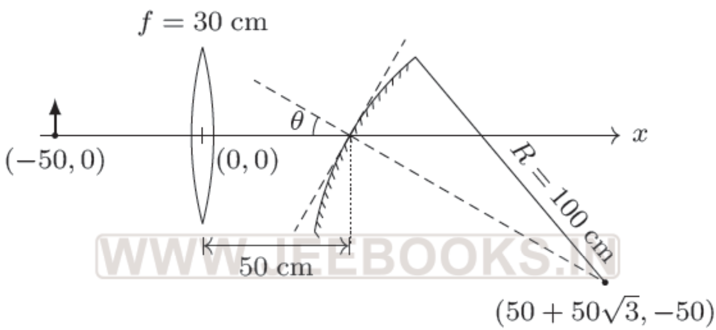
(A) 112 J (B) 294 J (C) 588 J (D) 813 J

Q 4. The end Q and R of two thin wires, PQ and RS, are soldered (joined) together. Initially each of the wires has a length of 1 m at 10 °C. Now the end P is maintained at 10 °C, while the end S is heated and maintained at 400 °C. The system is thermally insulated from its surroundings. If the thermal conductivity of wire PQ is twice that of the wire RS and the coefficient of linear thermal expansion of PQ is $1.2 \times 10^{-5}\ \mathrm{K}^{-1}$, the change in length of the wire PQ is

(A) 0.78 mm (B) 0.90 mm

(C) 1.56 mm (D) 2.34 mm

Q 5. A small object is placed 50 cm to the left of a thin convex lens of focal length 30 cm. A convex spherical mirror of radius of curvature 100 cm is placed to the right of the lens at a distance of 50 cm. The mirror is tilted such that the axis of the mirror is at an angle $\theta = 30°$ to the axis of the lens, as shown in the figure.



If the origin of the coordinate system is taken to be at the centre of the lens, the coordinates (in cm) of the point (x, y) at which the image is formed are

(A) $(0, 0)$ (B) $(50 - 25\sqrt{3}, 25)$

(C) $(25, 25\sqrt{3})$ (D) $(125/3, 25/\sqrt{3})$

Q 6. There are two Vernier calipers both of which have 1 cm divided into 10 equal divisions on the main scale. The Vernier scale of one of the calipers (C_1) has 10 equal divisions that correspond to 9 main scale divisions. The Vernier scale of the other caliper (C_2) has 10 equal divisions that correspond to 11 main scale divisions. The readings of the two calipers are shown in the figure. The measured values (in cm) by calipers C_1 and C_2, respectively are

(A) 2.85 and 2.82 (B) 2.87 and 2.83
(C) 2.87 and 2.86 (D) 2.87 and 2.87

One or More Option(s) Correct

This section contains 8 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened

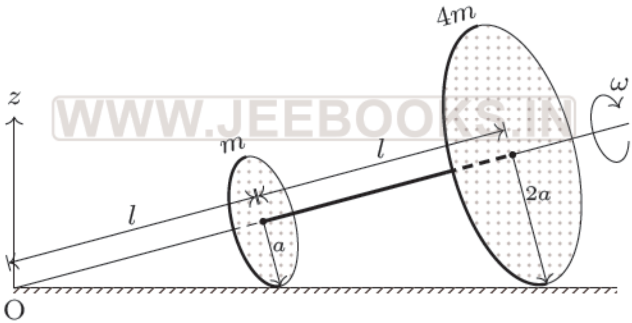
2. Partial Marks: (+1) For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened

3. Zero Marks: (0) If none of the bubbles is darkened

4. Negative Marks: (−2) In all other cases

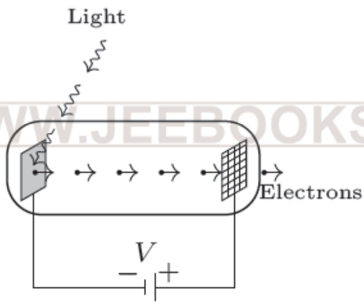
For example, if (A), (C) and (D) are all the correct options for a question, darkening all these three will get +4 marks; darkening only (A) and (D) will get +2 marks; and darkening (A) and (B) will get −2 marks, as a wrong option is also darkened.

Q 7. Two thin circular discs of mass m and $4m$, having radii of a and $2a$, respectively, are rigidly fixed by a massless, rigid rod of length $l = \sqrt{24}a$ through their centers. This assembly is laid on a firm and flat surface, and set rolling without slipping on the surface so that the angular speed about the axis of the rod is ω. The angular momentum of the entire assembly about the point 'O' is $\vec{L}$ (see the figure). Which of the following statement(s) is(are) true?



(A) The center of mass of the assembly rotates about the z-axis with an angular speed $\omega/5$.
(B) The magnitude of angular momentum of center of mass of the assembly about the point O is $81ma^2\omega$.
(C) The magnitude of angular momentum of the assembly about its center of mass is $17ma^2\omega/2$.
(D) The magnitude of the z-component of $\vec{L}$ is $55ma^2\omega$.

Q 8. Light of wavelength λ_{ph} falls on a cathode plate inside a vacuum tube as shown in the figure. The work function of the cathode surface is ϕ and the anode is a wire mesh of conducting material kept at a distance d from the cathode. A potential difference V is maintained between the electrodes. If the minimum de Broglie wavelength of the electron passing through the anode is λ_e, which of the following statement(s) is(are) true?



(A) λ_e decreases with increase in ϕ and λ_{ph}.
(B) λ_e is approximately halved, if d is doubled.
(C) For large potential difference ($V \gg \phi/e$), λ_e is approximately halved if V is made four times.
(D) λ_e increases at the same rate as λ_{ph} for $\lambda_{\text{ph}} < hc/\phi$.

Q 9. In an experiment to determine the acceleration due to gravity g, the formula used for the time period of a periodic motion is $T = 2\pi\sqrt{\frac{7(R-r)}{5g}}$. The values of R and r are measured to be (60 ± 1) mm and (10 ± 1) mm, respectively. In five successive measurements, the time period is found to be 0.52 s, 0.56 s, 0.57 s, 0.54 s and 0.59 s. The least count of the watch used for the measurement of time period is 0.01 s. Which of the following statement(s) is(are) true?

(A) The error in the measurement of r is 10%.

(B) The error in the measurement of T is 3.57%.

(C) The error in the measurement of T is 2%.

(D) The error in the determined value of g is 11%.

Q 10. Consider two identical galvanometers and two identical resistors with resistance R. If the internal resistance of the galvanometers $R_c < R/2$, which of the following statement(s) about any one of the galvanometers is(are) true?

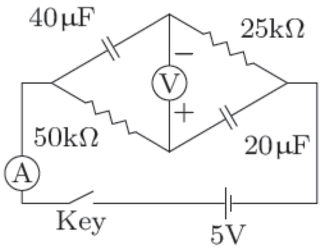
(A) The maximum voltage range is obtained when all the components are connected in series.

(B) The maximum voltage range is obtained when the two resistors and one galvanometer are connected in series, and the second galvanometer is connected in parallel to the first galvanometer.

(C) The maximum current range is obtained when all the components are connected in parallel.

(D) The maximum current range is obtained when the two galvanometers are connected in series and the combination is connected in parallel with both the resistors.

Q 11. In the circuit shown in the figure, the key is pressed at time $t = 0$. Which of the following statement(s) is(are) true?



(A) The voltmeter displays -5 V as soon as the key is pressed, and displays $+5$ V after a long time.

(B) The voltmeter will display 0 V at time $t = \ln 2$ seconds.
(C) The current in the ammeter becomes $1/e$ of the initial value after 1 second.
(D) The current in the ammeter becomes zero after a long time.

Q 12. A block with mass M is connected by a massless spring with stiffness constant k to a rigid wall and moves without friction on a horizontal surface. The block oscillates with small amplitude A about an equilibrium position x_0. Consider two cases: (1) when the block is at x_0; and (2) when the block is at $x = x_0 + A$. In both the cases, a particle with mass $m\,(< M)$ is softly placed on the block after which they stick to each other. Which of the following statement(s) is(are) true about the motion after the mass m is placed on the mass M?

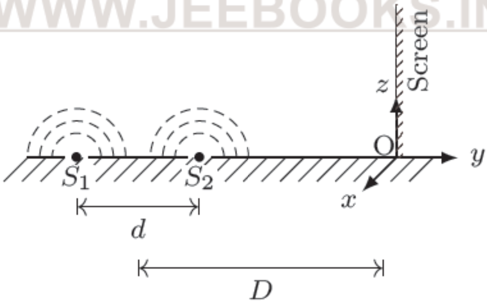
(A) The amplitude of oscillation in the first case changes by a factor of $\sqrt{\frac{M}{m+M}}$, whereas in the second case it remains unchanged.

(B) The final time period of oscillation in both the cases is same.

(C) The total energy decreases in both the cases.

(D) The instantaneous speed at x_0 of the combined masses decreases in both the cases.

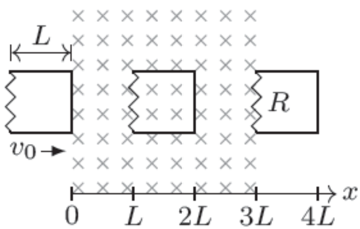
Q 13. While conducting the Young's double slit experiment, a student replaced the two slits with a large opaque plate in the x-y plane containing two small holes that act as two coherent point sources (S_1, S_2) emitting light of wavelength 600 nm. The student mistakenly placed the screen parallel to the x-z plane (for $z > 0$) at a distance $D = 3$ m from the mid-point of S_1S_2, as shown schematically in the figure. The distance between the sources is $d = 0.6003$ mm. The origin O is at the intersection of the screen and the line joining S_1S_2. Which of the following is(are) true of the intensity pattern on the screen?



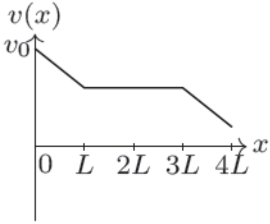
(A) Straight bright and dark bands parallel to the x-axis.
(B) The region very close to the point O will be dark.
(C) Hyperbolic bright and dark bands with foci symmetrically placed about O in the x-direction.

(D) Semi circular bright and dark bands centered at point O.

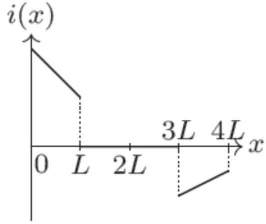
Q 14. A rigid wire loop of square shape having side of length L and resistance R is moving along the x-axis with a constant velocity v_0 in the plane of the paper. At $t = 0$, the right edge of the loop enters a region of length $3L$ where there is a uniform magnetic field B_0 into the plane of the paper, as shown in the figure. For sufficiently large v_0, the loop eventually crosses the region. Let x be the location of the right edge of the loop. Let $v(x)$, $i(x)$ and $F(x)$ represent the velocity of the loop, current in the loop, and force on the loop, respectively as a function of x. Counter-clockwise current is taken as positive. Which of the following schematic plot(s) is(are) correct? [Ignore gravity.]



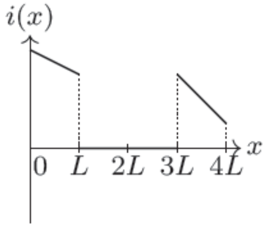
(A)



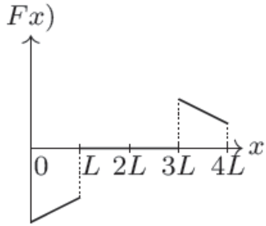
(B)



(C)



(D)



Paragraph Type

This section contains 4 questions based on two paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. For each question, marks will be awarded in one of the following categories:

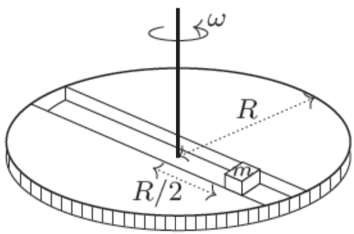
1. Full Marks: (+3) If only the bubble corresponding to the correct option is darkened
2. Zero Marks: (0) In all other cases

Paragraph for Questions 15-16

A frame of reference that is accelerated with respect to an inertial frame of reference is called a non-inertial frame of reference. A coordinate system fixed on a circular disc rotating about a fixed axis with a constant angular velocity ω is an example of a non-inertial frame of reference. The relationship between the force $\vec{F}_{\rm rot}$ experienced by a particle of mass m moving on the rotating disc and the force $\vec{F}_{\rm in}$ experienced by the particle in an inertial frame of reference is

$$\vec{F}_{\rm rot} = \vec{F}_{\rm in} + 2m(\vec{v}_{\rm rot} \times \vec{\omega}) + m(\vec{\omega} \times \vec{r}) \times \vec{\omega},$$

where $\vec{v}_{\rm rot}$ is the velocity of the particle in the rotating frame of reference and $\vec{r}$ is the position vector of the particle with respect to the centre of the disc.



Now consider a smooth slot along a diameter of a disc of radius R rotating counter-clockwise with a constant angular speed ω about its vertical axis through its center. We assign a coordinate system with the origin

at the center of the disc, the x-axis along the slot, the y-axis perpendicular to the slot and the z-axis along the rotation axis ($\vec{\omega} = \omega\hat{k}$). A small block of mass m is gently placed in the slot at $\vec{r} = (R/2)\,\hat{\imath}$ at $t = 0$ and is constrained to move only along the slot. (2016)

Q 15. The distance r of the block at time t is

(A) $\frac{R}{4}\left(e^{\omega t}+e^{-\omega t}\right)$ (B) $\frac{R}{2}\cos\omega t$

(C) $\frac{R}{4}\left(e^{2\omega t}+e^{-2\omega t}\right)$ (D) $\frac{R}{2}\cos 2\omega t$

Q 16. The net reaction of the disc on the block is

(A) $\frac{1}{2}m\omega^2 R\left(e^{2\omega t} - e^{-2\omega t}\right)\hat{\jmath} + mg\,\hat{k}$

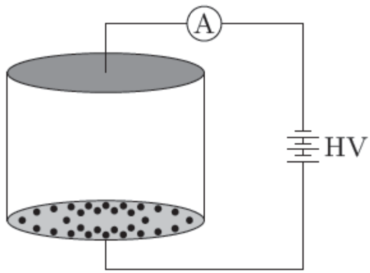
(B) $\frac{1}{2}m\omega^2 R\,(e^{\omega t} - e^{-\omega t})\,\hat{\jmath} + mg\,\hat{k}$

(C) $-m\omega^2 R\cos\omega t\,\hat{\jmath} - mg\,\hat{k}$

(D) $m\omega^2 R\sin\omega t\,\hat{\jmath} - mg\,\hat{k}$

Paragraph for Questions 17-18

Consider an evacuated cylindrical chamber of height h having rigid conducting plates at the ends and an insulating curved surface as shown in the figure. A number of spherical balls made of light weight and soft material and coated with a conducting material are placed on the bottom plate. The balls have a radius $r \ll h$. Now a high voltage source (HV) is connected across the conducting plates such that the bottom plate is at $+V_0$ and the top plate at $-V_0$. Due to their conducting surface, the balls will get charged, will become equipotential with the plate and are repelled by it. The balls will eventually collide with the top plate, where the coefficient of restitution can be taken to be zero due to the soft nature of the material of the balls. The electric field in the chamber can be considered to be that of a parallel plate capacitor. Assume that there are no collisions between the balls and the interaction between them is negligible. [Ignore gravity.] (2016)



Q 17. Which one of the following statements is correct?

(A) The balls will stick to the top plate and remain there.

(B) The balls will bounce back to the bottom plate carrying the same charge they went up with.

(C) The balls will bounce back to the bottom plate carrying the opposite charge they went up with.

(D) The balls will execute simple harmonic motion between the two plates.

Q 18. The average current in the steady state registered by the ammeter in the circuit will be
(A) zero
(B) proportional to the potential V_0
(C) proportional to $V_0^{1/2}$
(D) proportional to V_0^2

Answers

1. C
2. C
3. C
4. A
5. C
6. B
7. A, C
8. C
9. A, B, D
10. B, C
11. A, B, C, D
12. A, B, D
13. B, D
14. A, B
15. A
16. B
17. C
18. D

IIT JEE 2015

IIT JEE 2015 was a two stage examination (i) JEE Mains by CBSE and (ii) JEE Advanced by JAB. There were two papers in JEE Advanced namely, (Advanced) Paper 1 and (Advanced) Paper 2. Each of the papers has three separate parts for physics, chemistry and mathematics.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

(Advanced) Paper 1

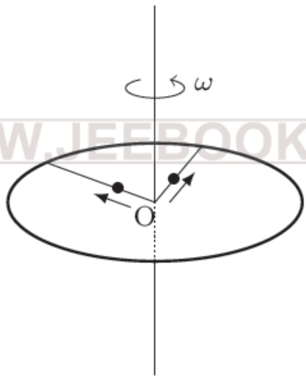
The physics part of the paper contains 20 questions of total marks 88. The questions are divided into three sections (1) integer type (2) multiple correct answers type and (3) matrix-matching type.

One or More Option(s) Correct

This section contains 10 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

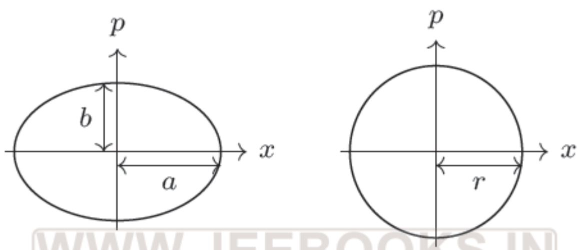
1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−2) In all other cases

Q 1. A ring of mass m and radius r is rotating with angular speed ω about a fixed vertical axis passing through its centre O with two point masses, each of mass $\frac{m}{8}$ at rest at O. These masses can move radially outwards along two massless rods fixed on the ring as shown in the figure. At some instant the angular speed of the system is $\frac{8}{9}\omega$ and one of the masses is at a distance of $\frac{3}{5}r$ from O. At this instant the distance of the other mass from O is



(A) $\frac{2}{3}r$ (B) $\frac{1}{3}r$ (C) $\frac{3}{5}r$ (D) $\frac{4}{5}r$

Q 2. Two independent harmonic oscillators of equal mass are oscillating about the origin with angular frequencies ω_1 and ω_2 and have total energies E_1 and E_2, respectively. The variations of their momenta p and position x are shown in the figures. If $a/b = n^2$ and $a/r = n$, then the correct equation(s) is (are)



Energy= E_1 Energy= E_2

(A) $E_1\omega_1 = E_2\omega_2$ (B) $\omega_2/\omega_1 = n^2$
(C) $\omega_1\omega_2 = n^2$ (D) $E_1/\omega_1 = E_2/\omega_2$

Q 3. Planck's constant h, speed of light c and gravitational constant G are used to form a unit of length L and a unit of mass M. Then the correct option(s) is (are)

(A) $M \propto \sqrt{c}$ (B) $M \propto \sqrt{G}$
(C) $L \propto \sqrt{h}$ (D) $L \propto \sqrt{G}$

Q 4. Consider a Vernier callipers in which each 1 cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale. In the Vernier callipers, 5 divisions of the Vernier scale coincide with 4 divisions on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then,

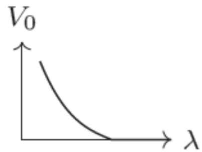
(A) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01 mm.

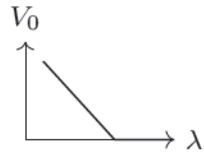
(B) If the pitch of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005 mm.

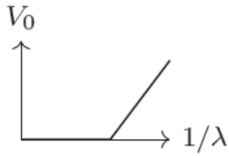
(C) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.01 mm.

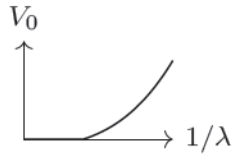
(D) If the least count of the linear scale of the screw gauge is twice the least count of the Vernier callipers, the least count of the screw gauge is 0.005 mm.

Q 5. For photo-electric effect with incident photon wavelength λ, the stopping potential is V_0. Identify the correct variation(s) of V_0 with λ and $1/\lambda$.

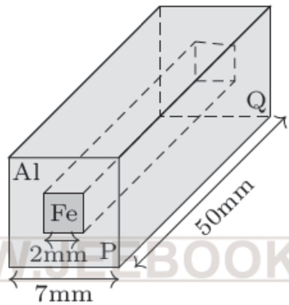
(A)


(B)


(C)


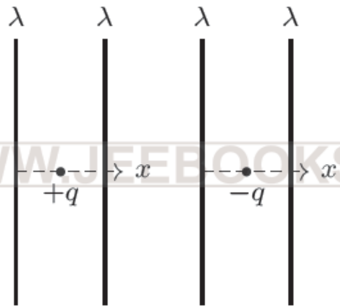
(D)


Q 6. In an aluminium (Al) bar of square cross-section, a square hole is drilled and is filled with iron (Fe) as shown in the figure. The electrical resistivities of Al and Fe are $2.7 \times 10^{-8}\ \Omega$ m and $1.0 \times 10^{-7}\ \Omega$ m, respectively. The electrical resistance between the two faces P and Q of the composite bar is



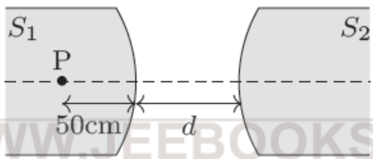
(A) $\frac{2475}{64}\ \mu\Omega$ (B) $\frac{1875}{64}\ \mu\Omega$ (C) $\frac{1875}{49}\ \mu\Omega$ (D) $\frac{2475}{132}\ \mu\Omega$

Q 7. The figure depicts two situations in which two infinitely long static line charges of constant positive line charge density λ are kept parallel to each other. In their resulting electric field, point charge q and $-q$ are kept in equilibrium between them. The point charges are confined to move in the x direction only. If they are given a small displacement about their equilibrium positions, then the correct statements(s) is (are)



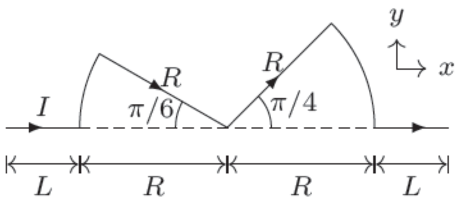
(A) Both charges execute SHM.
(B) Both charges will continue moving in the direction of their displacement.
(C) Charge $+q$ executes SHM while charge $-q$ continues moving in the direction of its displacement.
(D) Charge $-q$ executes SHM while charge $+q$ continues moving in the direction of its displacement.

Q 8. Two identical glass rods S_1 and S_2 (refractive index $= 1.5$) have one convex end of radius of curvature 10 cm. They are placed with the curved surface at a distance d as shown in the figure, with their axes (shown by the dashed line) aligned. When a point source of light P is placed inside rod S_1 on its axis at a distance of 50 cm from the curved face, the light rays emanating from it are found to be parallel to the axis inside S_2. The distance d is



(A) 60 cm (B) 70 cm (C) 80 cm (D) 90 cm

Q 9. A conductor (shown in the figure) carrying constant current I is kept in the x-y plane in a uniform magnetic field $\vec{B}$. If F is the magnitude of the total magnetic force acting on the conductor, then the correct statement(s) is (are)



(A) If $\vec{B}$ is along $\hat{z}$, $F \propto (L + R)$

(B) If $\vec{B}$ is along $\hat{x}$, $F = 0$

(C) If $\vec{B}$ is along $\hat{y}$, $F \propto (L + R)$

(D) If $\vec{B}$ is along $\hat{z}$, $F = 0$

Q 10. A container of fixed volume has a mixture of one mole of hydrogen and one mole of helium in equilibrium at temperature T. Assuming the gases are ideal, the correct statement(s) is (are)

(A) The average energy per mole of the gas mixture is $2RT$.

(B) The ratio of speed of sound in the gas mixture to that in helium gas is $\sqrt{6/5}$.

(C) The ratio of the rms speed of helium atoms to that of hydrogen molecules is $1/2$.

(D) The ratio of the rms speed of helium atoms to that of hydrogen molecules is $1/\sqrt{2}$.

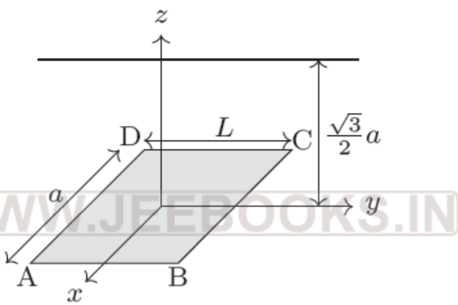
Integer Type

This section contains 8 questions. The answer to each question is a single digit integer ranging from 0 to 9, both inclusive. For each question, marks will be awarded in one of the following categories:

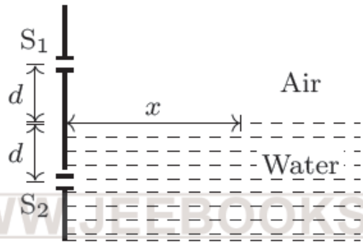
1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

Q 11. Consider a hydrogen atom with its electron in the n^{th} orbital. An electromagnetic radiation of wavelength 90 nm is used to ionize the atom. If the kinetic energy of the ejected electron is 10.4 eV, then the value of n is .... $[hc = 1242 \text{ eV nm}]$.

Q 12. An infinitely long uniform charge distribution of charge per unit length λ lies parallel to the y-axis in the y-z plane at $z = \frac{\sqrt{3}}{2}a$ (see figure). If the magnitude of the flux of the electric field through the rectangular surface ABCD lying in the x-y plane with its centre at the origin is $\lambda L/(n\epsilon_0)$ (ϵ_0 = permittivity of free space), then the value of n is ....

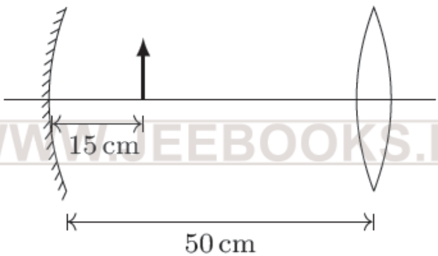


Q 13. A Young's double slit interference arrangement with slits S_1 and S_2 is immersed in water (refractive index = 4/3) as shown in the figure. The positions of maxima on the surface of water are given by $x^2 = p^2m^2\lambda^2 - d^2$, where λ is the wavelength of light in air (refractive index = 1), $2d$ is the separation between the slits and m is an integer. The value of p is ....



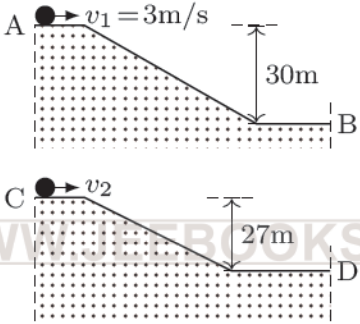
Q 14. A nuclear power plant supplying electrical power to a village uses a radioactive material of half life T years as the fuel. The amount of fuel at the beginning is such that the total power requirement of the village is 12.5% of the electrical power available from the plant at that time. If the plant is able to meet the total power needs of the village for a maximum period of nT years, then the value of n is ....

Q 15. Consider a concave mirror and a convex lens (refractive index = 1.5) of focal length 10 cm each, separated by a distance of 50 cm in air (refractive index = 1) as shown in the figure. An object is placed at a distance of 15 cm from the mirror. Its erect image formed by this combination has magnification m_1. When the set-up is kept in a medium of refractive index 7/6, the magnification becomes m_2. The magnitude $|m_2/m_1|$ is ....



Q 16. Two spherical stars A and B emits blackbody radiation. The radius of A is 400 times that of B and A emits 10^4 times the power emitted from B. The ratio λ_A/λ_B of their wavelengths λ_A and λ_B at which the peaks occur in their respective radiation curves is . . . .

Q 17. Two identical uniform discs roll without slipping on two different surfaces AB and CD (see figure) starting at A and C with linear speeds v_1 and v_2, respectively, and always remain in contact with the surface. If they reach B and D with the same linear speed and $v_1 = 3$ m/s, then v_2 in m/s is .... [$g = 10$ m/s^2.]



Q 18. A bullet is fired vertically upwards with velocity v from the surface of a spherical planet. When it reaches its maximum height, its acceleration due to the planet's gravity is $1/4^{\text{th}}$ of its value at the surface of the planet. If the escape velocity from the planet is $v_{\text{esc}} = v\sqrt{N}$, then the value of N is .... [ignore energy loss due to atmosphere.]

Matrix or Matching Type

This section contains two questions. Each question contains two columns, column I and column II. Column I has four entries (A), (B), (C) and (D). Column II has five entries (p), (q), (r), (s) and (t). Match the entries in column I with entries in column II. One or more entries in column I may match with one or more entries in column II. For each entry in column I, darken the bubbles of all the matching entries. For example, if entry (A) in column I matches with entries (q), (r) and (t), then darken these three bubbles in the ORS. Similarly, for entries (B), (C) and (D). Marking scheme for each entry in column I is:

1. Full Marks: (+2) If only the bubble(s) corresponding to the correct match(es) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Q 19. A particle of unit mass is moving along the x-axis under the influence of a force and its total energy is conserved. Four possible forms of the potential energy of the particle are given in *Column I* (a and U_0 are constants). Match the potential energies in *Column I* to the corresponding statement(s) in *Column II*.

Column I	Column II
(A) $U_1(x)=\frac{U_0}{2}\left[1-\left(\frac{x}{a}\right)^2\right]^2$	(p) The force acting on the particle is zero at $x=a$.
(B) $U_2(x)=\frac{U_0}{2}\left(\frac{x}{a}\right)^2$	(q) The force acting on the particle is zero at $x=0$.
(C) $U_3(x)=\frac{U_0}{2}\left(\frac{x}{a}\right)^2\exp\left[-\left(\frac{x}{a}\right)^2\right]$	(r) The force acting on the particle is zero at $x=-a$.
(D) $U_4(x)=\frac{U_0}{2}\left[\frac{x}{a}-\frac{1}{3}\left(\frac{x}{a}\right)^3\right]$	(s) The particle experiences an attractive force towards $x=0$ in the region $\lvert x\rvert<a$.
	(t) The particle with total energy $\frac{U_0}{4}$ can oscillate about the point $x=-a$.

Q 20. Match the nuclear processes given in *Column I* with the appropriate option(s) in *Column II*.

Column I	Column II
(A) Nuclear fusion	(p) Absorption of thermal neutron by $^{235}_{92}U$
(B) Fission in a nuclear reaction	(q) $^{60}_{27}Co$ nucleus
(C) β-decay	(r) Energy production in stars via hydrogen conversion to helium
(D) γ-ray emission	(s) Heavy water
	(t) Neutrino emission

Answers

1. D
2. B, D
3. A, C, D
4. B, C
5. A, C
6. B
7. C
8. B
9. A, B, C
10. A, B, D
11. 2
12. 6
13. 3
14. 3
15. 7
16. 2
17. 7
18. 2
19. A$\mapsto$(p, q, r, t), B$\mapsto$(q, s), C$\mapsto$(p,q,r, s), D$\mapsto$(p, r, t)
20. A$\mapsto$(r, t), B$\mapsto$(p, s), C$\mapsto$(q, t), D$\mapsto$(r)

(Advanced) Paper 2

The physics part of the paper contains 20 questions of total marks 80. The questions are divided into three sections (1) integer type (2) multiple correct answers type and (3) paragraph type.

Integer Type

This section contains 8 questions. The answer to each question is a single digit integer ranging from 0 to 9, both inclusive. For each question, marks will be awarded in one of the following categories:

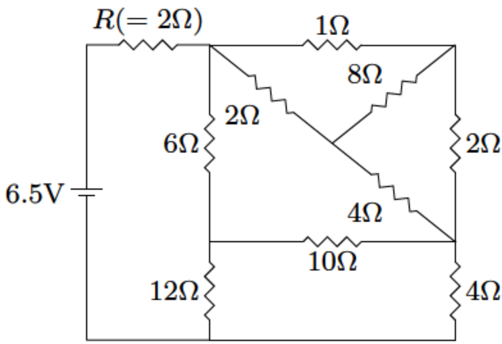
1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

Q 1. The energy of a system as a function of time t is given as $E(t) = A^2 \exp(-\alpha t)$, where $\alpha = 0.2\ \mathrm{s}^{-1}$. The measurement of A has an error of 1.25%. If the error in the measurement of time is 1.50%, the percentage error in the value of $E(t)$ at $t = 5$ s is ....

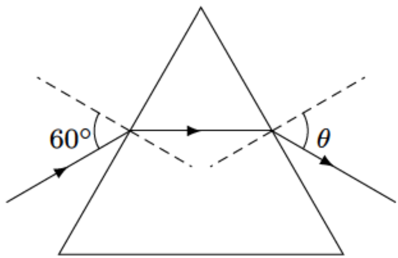
Q 2. A large spherical mass M is fixed at one position and two identical point masses m are kept on a line passing through the centre of M (see figure). The point masses are connected by a rigid massless rod of length l and this assembly is free to move along the line connecting them. All three masses interact only through their mutual gravitational interaction. When the point mass nearer to M is at a distance $r = 3l$ from M, the tension in the rod is zero for $m = k\left(\frac{M}{288}\right)$. The value of k is ....

Q 3. An electron in an excited state of Li^{2+} ion has angular momentum $3h/2\pi$. The de-Broglie wavelength of the electron in this state is $p\pi a_0$ (where a_0 is the Bohr radius). The value of p is ....

Q 4. In the following circuit, the current through the resistor $R(= 2\ \Omega)$ is I Amperes. The value of I is ....



Q 5. A monochromatic beam of light is incident at $60°$ on one face of an equilateral prism of refractive index n and emerges from the opposite face making an angle $\theta(n)$ with the normal (see figure). For $n = \sqrt{3}$ the value of θ is $60°$ and $\mathrm{d}\theta/\mathrm{d}n = m$. The value of m is ....



Q 6. For a radioactive material, its activity A and rate of change of its activity R are defined as $A = -\mathrm{d}N/\mathrm{d}t$ and $R = -\mathrm{d}A/\mathrm{d}t$, where $N(t)$ is the number of nuclei at time t. Two radioactive sources P (mean life τ) and Q (mean life 2τ) have the same activity at $t = 0$. Their rates of change of activities at $t = 2\tau$ are R_{P} and R_{Q}, respectively. If $R_{\mathrm{P}}/R_{\mathrm{Q}} = n/e$, then the value of n is ....

Q 7. Four harmonic waves of equal frequencies and equal intensities I_0 have phase angles 0, $\pi/3$, $2\pi/3$ and π. When they are superposed, the intensity of the resulting wave is nI_0. The value of n is ....

Q 8. The densities of two solid spheres A and B of the radii R vary with radial distance r as $\rho_A(r) = k\,(r/R)$ and $\rho_B(r) = k\,(r/R)^5$, respectively, where k is a constant. The moments of inertia of the individual spheres about axes passing through their centres are I_A and I_B, respectively. If $I_B/I_A = n/10$, the value of n is ....

One or More Option(s) Correct

This section contains 8 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−2) In all other cases

Q 9. A fission reaction is given by ${}^{236}_{92}\mathrm{U} \rightarrow {}^{140}_{54}\mathrm{Xe} + {}^{94}_{38}\mathrm{Sr} + x + y$, where x and y are two particles. Considering ${}^{236}_{92}\mathrm{U}$ to be at rest, the kinetic energies of the products are denoted by K_{Xe}, K_{Sr}, $K_{\mathrm{x}}(2\text{ MeV})$ and $K_{\mathrm{y}}(2\text{ MeV})$, respectively. Let the binding energies per nucleon of ${}^{236}_{92}\mathrm{U}$, ${}^{140}_{54}\mathrm{Xe}$, and ${}^{94}_{38}\mathrm{Sr}$ be 7.5 MeV, 8.5 MeV and 8.5 MeV, respectively. Considering different conservation laws, the correct option(s) is (are)

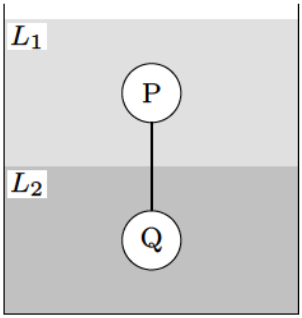
(A) $x = n$, $y = n$, $K_{\mathrm{Sr}} = 129$ MeV, $K_{\mathrm{Xe}} = 86$ MeV

(B) $x = p$, $y = e^-$, $K_{\mathrm{Sr}} = 129$ MeV, $K_{\mathrm{Xe}} = 86$ MeV

(C) $x = p$, $y = n$, $K_{\mathrm{Sr}} = 129$ MeV, $K_{\mathrm{Xe}} = 86$ MeV

(D) $x = n$, $y = n$, $K_{\mathrm{Sr}} = 86$ MeV, $K_{\mathrm{Xe}} = 129$ MeV

Q 10. Two spheres P and Q of equal radii have densities ρ_1 and ρ_2, respectively. The spheres are connected by a massless string and placed in liquids L_1 and L_2 of densities σ_1 and σ_2 and viscosities η_1 and η_2, respectively. They float in equilibrium with the sphere P in L_1 and sphere Q in L_2 and the string being taut (see figure). If sphere P alone in L_2 has terminal velocity $\vec{v}_{\mathrm{P}}$ and Q alone in L_1 has terminal velocity $\vec{v}_{\mathrm{Q}}$, then



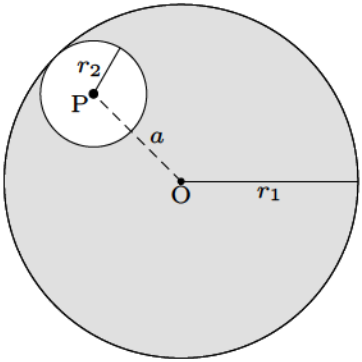
(A) $\frac{|\vec{v}_{\mathrm{P}}|}{|\vec{v}_{\mathrm{Q}}|} = \frac{\eta_1}{\eta_2}$ (B) $\frac{|\vec{v}_{\mathrm{P}}|}{|\vec{v}_{\mathrm{Q}}|} = \frac{\eta_2}{\eta_1}$
(C) $\vec{v}_{\mathrm{P}} \cdot \vec{v}_{\mathrm{Q}} > 0$ (D) $\vec{v}_{\mathrm{P}} \cdot \vec{v}_{\mathrm{Q}} < 0$

Q 11. In terms of potential difference V, electric current I, permittivity ϵ_0, permeability μ_0 and speed of light c, the dimensionally correct equation(s) is (are)

(A) $\mu_0 I^2 = \epsilon_0 V^2$ (B) $\epsilon_0 I = \mu_0 V$

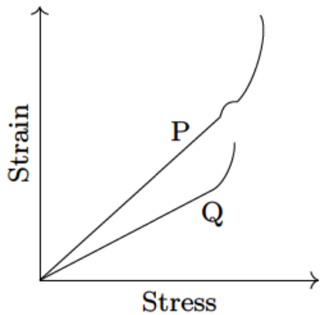
(C) $I = \epsilon_0 c V$ (D) $\mu_0 c I = \epsilon_0 V$

Q 12. Consider a uniform spherical charge distribution of radius r_1 centered at the origin O. In this distribution, a spherical cavity of radius r_2, centered at P with distance OP $= a = r_1 - r_2$ (see figure) is made. If the electric field inside the cavity at position $\vec{r}$ is $\vec{E}(\vec{r})$, then the correct statement(s) is (are)



(A) $\vec{E}$ is uniform, its magnitude is independent of r_2 but its direction depends on $\vec{r}$.
(B) $\vec{E}$ is uniform, its magnitude depends on r_2 and its direction depends on $\vec{r}$.
(C) $\vec{E}$ is uniform, its magnitude is independent of a but its direction depends on $\vec{a}$.
(D) $\vec{E}$ is uniform and both its magnitude and direction depend on $\vec{a}$.

Q 13. In plotting stress *versus* strain curves for two materials P and Q, a student by mistake puts strain on the y-axis and stress on the x-axis as shown in the figure. Then the correct statement(s) is (are)



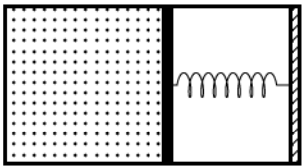
(A) P has more tensile strength than Q.
(B) P is more ductile than Q.
(C) P is more brittle than Q.
(D) The Young's modulus of P is more than that of Q.

Q 14. A spherical body of radius R consists of a fluid of constant density and is in equilibrium under its own gravity. If $P(r)$ is the pressure at $r(r < R)$, then the correct option(s) is (are)

(A) $P(r = 0) = 0$ (B) $\frac{P(r=3R/4)}{P(r=2R/3)} = \frac{63}{80}$

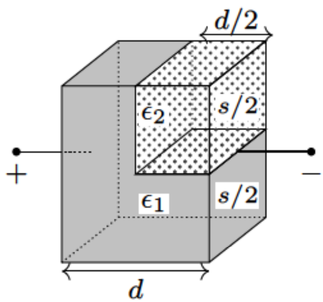
(C) $\frac{P(r=3R/5)}{P(r=2R/5)} = \frac{16}{21}$ (D) $\frac{P(r=R/2)}{P(r=R/3)} = \frac{20}{27}$

Q 15. An ideal monatomic gas is confined in a horizontal cylinder by a spring loaded piston (as shown in the figure). Initially the gas is at temperature T_1, pressure p_1 and volume V_1 and the spring is in its relaxed state. The gas is then heated very slowly to temperature T_2, pressure p_2 and volume V_2. During the process the piston moves out by a distance x. Ignoring the friction between the piston and the cylinder, the correct statement(s) is (are)



(A) If $V_2 = 2V_1$ and $T_2 = 3T_1$, then the energy stored in the spring is $\frac{1}{4}p_1V_1$.
(B) If $V_2 = 2V_1$ and $T_2 = 3T_1$, then the change in internal energy is $3p_1V_1$.
(C) If $V_2 = 3V_1$ and $T_2 = 4T_1$, then the work done by the gas is $\frac{7}{3}p_1V_1$.
(D) If $V_2 = 3V_1$ and $T_2 = 4T_1$, then the heat supplied to the gas is $\frac{17}{6}p_1V_1$.

Q 16. A parallel plate capacitor having plates of area s and plate separation d, has capacitance C_1 in air. When two dielectrics of different relative permittivities ($\epsilon_1 = 2$ and $\epsilon_2 = 4$) are introduced between the two plates as shown in the figure, the capacitance becomes C_2. The ratio C_2/C_1 is



(A) 6/5 (B) 5/3 (C) 7/5 (D) 7/3

Paragraph Type

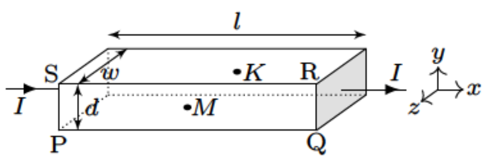
This section contains 4 questions based on two paragraphs. Each question has four options (A), (B), (C) and (D). One or more than one of these four option(s) is (are) correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−2) In all other cases

Paragraph for Questions 17-18

In a thin rectangular metallic strip a constant current I flows along the positive x-direction, as shown in the figure. The length, width and thickness of the strip are l, w and d, respectively. A uniform magnetic field $\vec{B}$ is applied on the strip along the positive y-direction. Due to this, the charge carriers experience a net deflection along the z-direction. This results in accumulation of charge carriers on the surface PQRS and appearance of equal and opposite charges on the face opposite to PQRS. A potential difference along the z-direction is thus developed. Charge accumulation continues until the magnetic force is balanced by the electric force. The current is assumed to be uniformly distributed on the cross section of the strip and carried by electrons.

(2015)



Q 17. Consider two different metallic strips (1 and 2) of the same material. Their lengths are the same, widths are w_1 and w_2 and thicknesses are d_1 and d_2, respectively. Two points K and M are symmetrically located on the opposite faces parallel to the x-y plane (see figure). V_1 and V_2 are the potential differences between K and M in strips 1 and 2, respectively. Then, for a given current I flowing through them in a given magnetic field strength B, the correct statement(s) is (are)

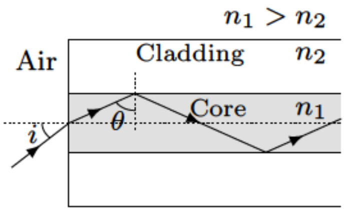
(A) If $w_1 = w_2$ and $d_1 = 2d_2$, then $V_2 = 2V_1$.
(B) If $w_1 = w_2$ and $d_1 = 2d_2$, then $V_2 = V_1$.
(C) If $w_1 = 2w_2$ and $d_1 = d_2$, then $V_2 = 2V_1$.
(D) If $w_1 = 2w_2$ and $d_1 = d_2$, then $V_2 = V_1$.

Q 18. Consider two different metallic strips (1 and 2) of same dimensions (length l, width w and thickness d) with carrier densities n_1 and n_2, respectively. Strip 1 is placed in magnetic field B_1 and strip 2 is placed in magnetic field B_2, both along positive y-directions. Then V_1 and V_2 are the potential differences developed between K and M in strips 1 and 2, respectively. Assuming that the current I is the same for both the strips, the correct options(s) is (are)
(A) If $B_1 = B_2$ and $n_1 = 2n_2$, then $V_2 = 2V_1$.
(B) If $B_1 = B_2$ and $n_1 = 2n_2$, then $V_2 = V_1$.
(C) If $B_1 = 2B_2$ and $n_1 = n_2$, then $V_2 = 0.5V_1$.
(D) If $B_1 = 2B_2$ and $n_1 = n_2$, then $V_2 = V_1$.

Paragraph for Questions 19-20

Light guidance in an optical fiber can be understood by considering a structure comprising of thin solid glass cylinder of refractive index n_1 surrounded by a medium of lower refractive index n_2. The light guidance in the structure takes place due to successive total internal reflections at the interface of the media n_1 and n_2 as shown in the figure. All rays with the angle of incidence i less than a particular value i_m are confined in the medium of refractive index n_1. The numerical aperture (NA) of the structure is defined as $\sin i_m$.

(2015)



Q 19. For two structures namely S_1 with $n_1 = \sqrt{45}/4$ and $n_2 = 3/2$, and S_2 with $n_1 = 8/5$ and $n_2 = 7/5$ and taking refractive index of water to be 4/3 and that of air to be 1, the correct option(s) is (are)

(A) NA of S_1 immersed in water is the same as that of S_2 immersed in a liquid of refractive index $16/3\sqrt{15}$.

(B) NA of S_1 immersed in liquid of refractive index $6/\sqrt{15}$ is the same as that of S_2 immersed in water.

(C) NA of S_1 placed in air is the same as that of S_2 immersed in liquid of refractive index $4/\sqrt{15}$.

(D) NA of S_1 placed in air is the same as that of S_2 placed in water.

Q 20. If two structures of same cross-sectional area, but different numerical apertures NA_1 and NA_2 ($\mathrm{NA}_2 < \mathrm{NA}_1$) are joined longitudinally, the numerical aperture of the combined structure is

(A) $\frac{\mathrm{NA}_1 \mathrm{NA}_2}{\mathrm{NA}_1 + \mathrm{NA}_2}$ (B) $\mathrm{NA}_1 + \mathrm{NA}_2$ (C) NA_1 (D) NA_2

Answers

1. 4
2. 7
3. 2
4. 1
5. 2
6. 2
7. 3
8. 6
9. A
10. A, D
11. A, C
12. D
13. A, B
14. B, C
15. A, B, C
16. D
17. A, D
18. A, C
19. A, C
20. D

IIT JEE 2014

IIT JEE 2014 was a two stage examination (i) JEE Mains by CBSE and (ii) JEE Advanced by JAB. There were two papers in JEE Advanced namely, (Advanced) Paper 1 and (Advanced) Paper 2. Each of the papers has three separate parts for physics, chemistry and mathematics.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

(Advanced) Paper 1

The physics part of the paper contains 20 questions. The questions are divided into two sections (1) integer type and (2) multiple correct answers type.

Integer Type

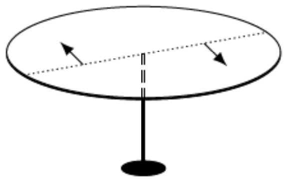
This section contains 10 questions. The answer to each question is a single digit integer ranging from 0 to 9, both inclusive. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

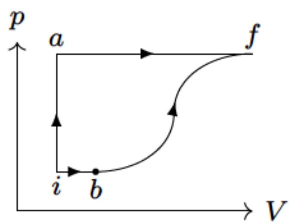
Q 1. A galvanometer gives full scale deflection with 0.006 A current. By connecting it to a 4990 Ω resistance, it can be converted into a voltmeter of range $0-30$ V. If connected to a $\frac{2n}{249}\,\Omega$ resistance, it becomes an ammeter of range $0-1.5$ A. The value of n is ....

Q 2. To find the distance d over which a signal can be seen clearly in foggy conditions, a railways engineer uses dimensional analysis and assumes that the distance depends on the mass density ρ of the fog, intensity (power/area) S of the light from the signal and its frequency f. The engineer finds that d is proportional to $S^{1/n}$. The value of n is ....

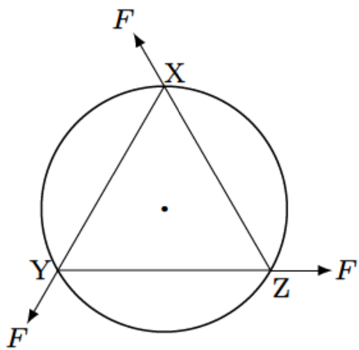
Q 3. A horizontal circular platform of radius 0.5 m and mass 0.45 kg is free to rotate about its axis. Two massless spring toy-guns, each carrying a steel ball of mass 0.05 kg are attached to the platform at a distance 0.25 m from the centre on its either sides along its diameter (see figure). Each gun simultaneously fires the balls horizontally and perpendicular to the diameter in opposite directions. After leaving the platform, the balls have horizontal speed of 9 m/s with respect to the ground. The rotational speed of the platform in rad/s after the balls leave the platform is . . . .



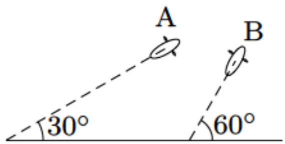
Q 4. A thermodynamic system is taken from an initial state i with internal energy $U_{\mathrm{i}} = 100$ J to the final state f along two different paths iaf and ibf, as schematically shown in the figure. The work done by the system along the path af, ib and bf are $W_{\mathrm{af}} = 200$ J, $W_{\mathrm{ib}} = 50$ J and $W_{\mathrm{bf}} = 100$ J respectively. The heat supplied to the system along the path iaf, ib and bf are Q_{iaf}, Q_{ib} and Q_{bf} respectively. If the internal energy of the system in the state b is $U_{\mathrm{b}} = 200$ J and $Q_{\mathrm{iaf}} = 500$ J, the ratio $Q_{\mathrm{bf}}/Q_{\mathrm{ib}}$ is ....



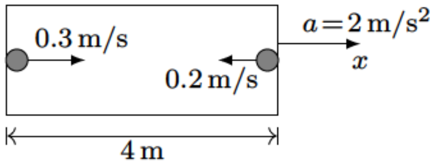
Q 5. A uniform circular disc of mass 2.5 kg and radius 0.5 m is initially at rest on a horizontal frictionless surface. Three forces of equal magnitude $F = 0.5$ N are applied simultaneously along the three sides of an equilateral triangle XYZ with its vertices on the perimeter of the disc (see figure). One second after applying the forces, the angular speed of the disc in rad/s is ....



Q 6. Airplanes A and B are flying with constant velocity in the same vertical plane at angles 30° and 60° with respect to the horizontal respectively as shown in the figure. The speed of A is $100\sqrt{3}$ m/s. At time $t = 0$ s, an observer in A finds B at a distance of 500 m. This observer sees B moving with a constant velocity perpendicular to the line of motion of A. If at $t = t_0$, A just escapes being hit by B, t_0 in seconds is ....



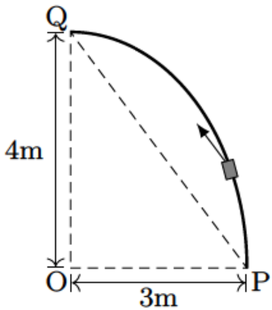
Q 7. A rocket is moving in a gravity free space with a constant acceleration of 2 m/s^2 along $+x$ direction (see figure). The length of a chamber inside the rocket is 4 m. A ball is thrown from the left end of the chamber in $+x$ direction with a speed of 0.3 m/s relative to the rocket. At the same time, another ball is thrown in $-x$ direction with a speed of 0.2 m/s from its right end relative to the rocket. The time in seconds when the two balls hit each other is ....



Q 8. During Searle's experiment, zero of the Vernier scale lies between 3.20×10^{-2} m and 3.25×10^{-2} m of the main scale. The 20^{th} division of the Vernier scale exactly coincides with one of the main scale divisions. When an additional load of 2 kg is applied to the wire, the zero of the Vernier scale still lies between 3.20×10^{-2} m and 3.25×10^{-2} m of the main scale but now 45^{th} division of Vernier scale coincides with one of the main scale divisions. The length of the thin metallic wire is 2 m and its cross-sectional area is 8×10^{-7} m^2. The least count of the Vernier scale is 1.0×10^{-5} m. The maximum percentage error in the Young's modulus of the wire is ....

Q 9. Two parallel wires in the plane of the paper are distance x_0 apart. A point charge is moving with speed v between the wires in the same plane at a distance x_1 from one of the wires. When the wires carry current of magnitude I in the same direction, the radius of curvature of the path of the point charge is r_1. In contrast, if the currents I in the two wires have directions opposite to each other, the radius of curvature of the path is r_2. If $\frac{x_0}{x_1} = 3$, the value of $\frac{r_1}{r_2}$ is ....

Q 10. Consider an elliptically shaped rail PQ in the vertical plane with OP = 3 m and OQ = 4 m. A block of mass 1 kg is pulled along the rail from P to Q with a force of 18 N, which is always parallel to line PQ (see figure). Assuming no frictional losses, the kinetic energy of the block when it reaches Q is $(n \times 10)$ Joules. The value of n is .... [Given $g = 10$ m/s^2.]

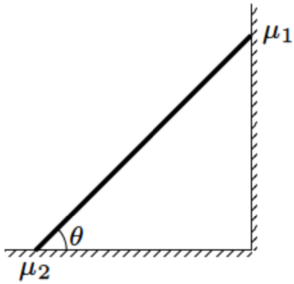


One or More Option(s) Correct

This section contains 10 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

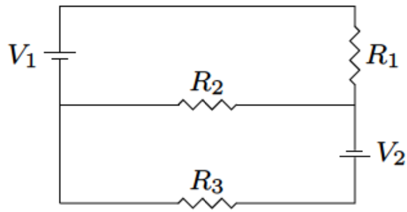
1. Full Marks: (+3) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened

Q 11. In the figure, a ladder of mass m is shown leaning against a wall. It is in static equilibrium making an angle θ with the horizontal floor. The coefficient of friction between the wall and the ladder is μ_1 and that between the floor and the ladder is μ_2. The normal reaction of the wall on the ladder is N_1 and that of the floor is N_2. If the ladder is about to slip, then



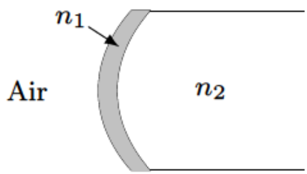
(A) $\mu_1 = 0$, $\mu_2 \neq 0$ and $N_2 \tan\theta = \frac{mg}{2}$
(B) $\mu_1 \neq 0$, $\mu_2 = 0$ and $N_1 \tan\theta = \frac{mg}{2}$
(C) $\mu_1 \neq 0$, $\mu_2 \neq 0$ and $N_2 = \frac{mg}{1+\mu_1\mu_2}$
(D) $\mu_1 = 0$, $\mu_2 \neq 0$ and $N_1 \tan\theta = \frac{mg}{2}$

Q 12. Two ideal batteries of *emf* V_1 and V_2 and three resistances R_1, R_2 and R_3 are connected as shown in the figure. The current in resistance R_2 would be zero if



(A) $V_1 = V_2$ and $R_1 = R_2 = R_3$
(B) $V_1 = V_2$ and $R_1 = 2R_2 = R_3$
(C) $V_1 = 2V_2$ and $2R_1 = 2R_2 = R_3$
(D) $2V_1 = V_2$ and $2R_1 = R_2 = R_3$

Q 13. A transparent thin film of uniform thickness and refractive index $n_1 = 1.4$ is coated on the convex spherical surface of radius R at one end of a long solid glass cylinder of refractive index $n_2 = 1.5$, as shown in the figure. Rays of light parallel to the axis of the cylinder traversing through the film from air to glass get focused at distance f_1 from the film, while rays of light traversing from glass to air get focused at distance f_2 from the film. Then,



(A) $|f_1| = 3R$ (B) $|f_1| = 2.8R$
(C) $|f_2| = 2R$ (D) $|f_2| = 1.4R$

Q 14. Let $E_1(r)$, $E_2(r)$ and $E_3(r)$ be the respective electric fields at a distance r from a point charge Q, an infinitely long wire with constant linear charge density λ, and an infinite plane with uniform surface charge density σ. If $E_1(r_0) = E_2(r_0) = E_3(r_0)$ at a given distance r_0, then

(A) $Q = 4\pi\sigma r_0^2$ (B) $r_0 = \frac{\lambda}{2\pi\sigma}$
(C) $E_1(\frac{r_0}{2}) = 2E_2(\frac{r_0}{2})$ (D) $E_2(\frac{r_0}{2}) = 4E_3(\frac{r_0}{2})$

Q 15. One end of a taut string of length 3 m along the x axis is fixed at $x = 0$. The speed of the waves in the string is 100 m/s. The other end of the string is vibrating in the y direction so that stationary waves are set up in the string. The possible waveform(s) of these stationary waves is (are)

(A) $y(x,t) = A \sin \frac{\pi x}{6} \cos \frac{50\pi t}{3}$
(B) $y(x,t) = A \sin \frac{\pi x}{3} \cos \frac{100\pi t}{3}$
(C) $y(x,t) = A \sin \frac{5\pi x}{6} \cos \frac{250\pi t}{3}$
(D) $y(x,t) = A \sin \frac{5\pi x}{2} \cos 250\pi t$

Q 16. Heater of an electric kettle is made of a wire of length L and diameter d. It takes 4 minutes to raise the temperature of 0.5 kg water by 40 K. This heater is replaced by a new heater having two wires of the same material, each of length L and diameter $2d$. The way these wires are connected is given in options. How much time in minutes will it take to raise the temperature of the same amount of water by 40 K?

(A) 4 if wires are in parallel
(B) 2 if wires are in series
(C) 1 if wires are in series
(D) 0.5 if wires are in parallel

Q 17. A light source, which emits two wavelengths $\lambda_1 = 400\,\text{nm}$ and $\lambda_2 = 600\,\text{nm}$, is used in Young's double slit experiment. If recorded fringe widths for λ_1 and λ_2 are β_1 and β_2 and the number of fringes for them within a distance y on one side of the central maximum are m_1 and m_2, respectively, then

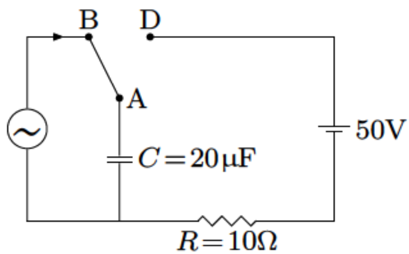
(A) $\beta_2 > \beta_1$

(B) $m_1 > m_2$

(C) From the central maximum, 3^{rd} maximum of λ_2 overlaps with 5^{th} minimum of λ_1

(D) The angular separation of fringes of λ_1 is greater than λ_2

Q 18. At time $t = 0$, terminal A in the circuit shown in the figure is connected to B by a key and an alternating current $i(t) = i_0 \cos(\omega t)$, with $i_0 = 1$ A and $\omega = 500$ rad/s starts flowing in it with initial direction shown in the figure. At $t = \frac{7\pi}{6\omega}$, the key is switched from B to D. Now onwards only A and D are connected. A total charge Q flows from the battery to charge the capacitor fully. If $C = 20\ \mu$F, $R = 10\ \Omega$ and the battery is ideal with *emf* of 50 V, identify the correct statement (s).



(A) Magnitude of the maximum charge on the capacitor before $t = \frac{7\pi}{6\omega}$ is 1×10^{-3} C.
(B) The current in the left part of the circuit just before $t = \frac{7\pi}{6\omega}$ is clockwise.
(C) Immediately after A is connected to D, the current in R is 10 A.
(D) $Q = 2 \times 10^{-3}$ C.

Q 19. A student is performing an experiment using a resonance column and a tuning fork of frequency $244\,\mathrm{s}^{-1}$. He is told that the air in the tube has been replaced by another gas (assume that the column remains filled with the gas). If the minimum height at which resonance occurs is (0.350 ± 0.005) m, the gas in the tube is [*Given:* $\sqrt{167RT} = 640\ \mathrm{J}^{1/2}\mathrm{mol}^{-1/2}$, $\sqrt{140RT} = 590\ \mathrm{J}^{1/2}\mathrm{mol}^{-1/2}$. The molar masses M in grams are given in the options. Take the value of $\sqrt{\frac{10}{M}}$ for each gas as given there.]

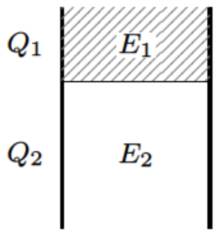
(A) Neon $\left(M=20, \sqrt{\frac{10}{20}} = \frac{7}{10}\right)$

(B) Nitrogen $\left(M=28, \sqrt{\frac{10}{28}} = \frac{3}{5}\right)$

(C) Oxygen $\left(M=32, \sqrt{\frac{10}{32}} = \frac{9}{16}\right)$

(D) Argon $\left(M=36, \sqrt{\frac{10}{36}} = \frac{17}{32}\right)$

Q 20. A parallel plate capacitor has a dielectric slab of dielectric constant K between its plates that covers 1/3 of the area of its plates, as shown in the figure. The total capacitance of the capacitor is C while that of the portion with dielectric in between is C_1. When the capacitor is charged, the plate area covered by the dielectric gets charge Q_1 and the rest of the area gets charge Q_2. The electric field in the dielectric is E_1 and that in the other portion is E_2. Choose the correct option/options, ignoring edge effects.



(A) $\frac{E_1}{E_2} = 1$ (B) $\frac{E_1}{E_2} = \frac{1}{K}$

(C) $\frac{Q_1}{Q_2} = \frac{3}{K}$ (D) $\frac{C}{C_1} = \frac{2+K}{K}$

Answers

1. 5
2. 3
3. 4
4. 2
5. 2
6. 5
7. 2
8. 4
9. 3
10. 5
11. C, D
12. A, B, D
13. A, C
14. C
15. A, C, D
16. B, D
17. A, B, C
18. C, D
19. D
20. A, D

(Advanced) Paper 2

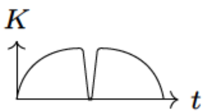
The physics part of the paper contains 20 questions. The questions are divided into three sections (1) single answer correct type (2) paragraph type and (3) matrix-matching type.

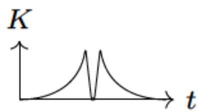
One Option Correct

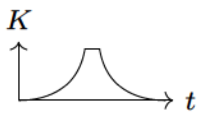
This section contains 10 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

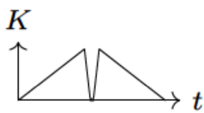
1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Q 1. A tennis ball is dropped on a horizontal smooth surface. It bounces back to its original position after hitting the surface. The force on the ball during the collision is proportional to the the length of compression of the ball. Which one of the following sketches describes the variation of its kinetic energy K with time t most appropriately? The figures are only illustrative and not to the scale.

(A)


(B)


(C)


(D)


Q 2. If λ_{Cu} is the wavelength of K_α X-ray line of copper (atomic number 29) and λ_{Mo} is the wavelength of the K_α X-ray line of molybdenum (atomic number 42), the the ratio $\lambda_{\mathrm{Cu}}/\lambda_{\mathrm{Mo}}$ is close to
(A) 1.99 (B) 2.14 (C) 0.50 (D) 0.48

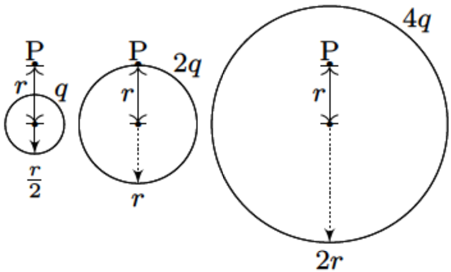
Q 3. A metal surface is illuminated by light of two different wavelengths 248 nm and 310 nm. The maximum speeds of the photoelectrons corresponding to these wavelengths are u_1 and u_2, respectively. If the ratio $u_1 : u_2 = 2 : 1$ and $hc = 1240$ eV nm, the work function of the metal is nearly

(A) 3.7 eV (B) 3.2 eV (C) 2.8 eV (D) 2.5 eV

Q 4. A planet of radius $R = \frac{1}{10} \times$ (radius of Earth) has the same mass density as Earth. Scientists dig well of depth $\frac{R}{5}$ on it and lower a wire of the same length and of linear mass density 10^{-3} kg/m into it. If the wire is not touching anywhere, the force applied at the top of the wire by a person holding it in place is [take the radius of Earth $= 6 \times 10^6$ m and the acceleration due to gravity on Earth $= 10\ \mathrm{m/s^2}$.]

(A) 96 N (B) 108 N (C) 120 N (D) 150 N

Q 5. Charges q, $2q$ and $4q$ are uniformly distributed in three dielectric solid spheres 1, 2 and 3 of radii $r/2$, r and $2r$ respectively, as shown in the figure. If magnitude of the electric fields at point P at a distance r from the centre of spheres 1, 2 and 3 are E_1, E_2 and E_3 respectively, then

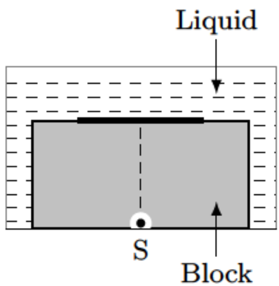


(A) $E_1 > E_2 > E_3$ (B) $E_3 > E_1 > E_2$
(C) $E_2 > E_1 > E_3$ (D) $E_3 > E_2 > E_1$

Q 6. Parallel rays of light of intensity $I = 912\ \mathrm{Wm^{-2}}$ are incident on a spherical black body kept in surroundings of temperature 300 K. Take Stefan-Boltzmann constant $\sigma = 5.7 \times 10^{-8}\ \mathrm{Wm^{-2}K^{-4}}$ and assume that the energy exchange with the surroundings is only through radiation. The final steady state temperature of the black body is close to

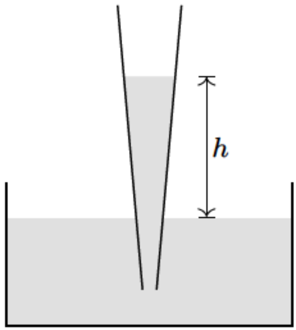
(A) 330 K (B) 660 K (C) 990 K (D) 1550 K

Q 7. A point source S is placed at the bottom of a transparent block of height 10 mm and refractive index 2.72. It is immersed in a lower refractive index liquid as shown in the figure. It is found that the light emerging from the block to the liquid forms a circular bright spot of diameter 11.54 mm on the top of the block. The refractive index of the liquid is



(A) 1.21 (B) 1.30 (C) 1.36 (D) 1.42

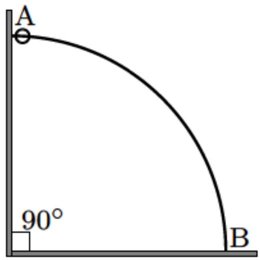
Q 8. A glass capillary tube is of the shape of a truncated cone with an apex angle α so that its two ends have cross sections of different radii. When dipped in water vertically, water rises in it to a height h, where the radius of its cross-section is b. If the surface tension of water is S, its density is ρ, and its contact angle with glass is θ, the value of h will be (where g is acceleration due to gravity)



(A) $\frac{2S}{b\rho g}\cos(\theta-\alpha)$ (B) $\frac{2S}{b\rho g}\cos(\theta+\alpha)$

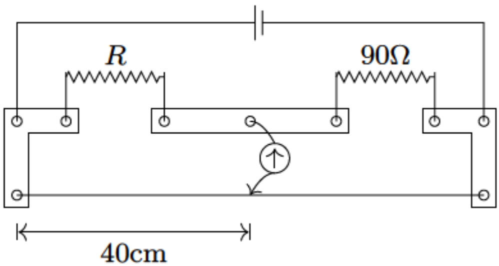
(C) $\frac{2S}{b\rho g}\cos(\theta-\alpha/2)$ (D) $\frac{2S}{b\rho g}\cos(\theta+\alpha/2)$

Q 9. A wire, which passes through the hole in a small bead, is bent in the form of a quarter of a circle. The wire is fixed vertically on ground as shown in the figure. The bead is released from near the top of the wire and it slides along the wire without friction. As the bead moves from A to B, the force it applies on the wire is



(A) always radially outwards.
(B) always radially inwards.
(C) radially outwards initially and radially inwards later.
(D) radially inwards initially and radially outwards later.

Q 10. During an experiment with a metre bridge, the galvanometer shows a null point when the jockey is pressed at 40.0 cm using a standard resistance of 90 Ω, as shown in the figure. The least count of the scale used in the metre bridge is 1 mm. The unknown resistance is



(A) $60 \pm 0.15\ \Omega$ (B) $135 \pm 0.56\ \Omega$
(C) $60 \pm 0.25\ \Omega$ (D) $135 \pm 0.23\ \Omega$

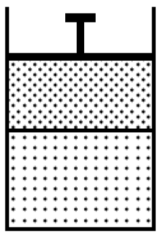
Paragraph Type

This section contains 6 questions based on three paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 11-12

In the figure a container is shown to have a movable (without friction) piston on top. The container and the piston are all made of perfectly insulating material allowing no heat transfer between outside and inside the container. The container is divided into two compartments by a rigid partition made of a thermally conducting material that allows slow transfer of heat. The lower compartment of the container is filled with 2 moles of an ideal monatomic gas at 700 K and the upper compartment is filled with 2 moles of an ideal diatomic gas at 400 K. The heat capacities per mole of an ideal monatomic gas are $C_v = \frac{3}{2}R$, $C_p = \frac{5}{2}R$, and those for an ideal diatomic gas are $C_v = \frac{5}{2}R$, $C_p = \frac{7}{2}R$.
(2014)

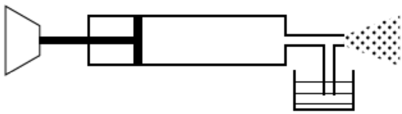


Q 11. Consider the partition to be rigidly fixed so that it does not move. When equilibrium is achieved, the final temperature of the gases will be
(A) 550 K (B) 525 K (C) 513 K (D) 490 K

Q 12. Now consider the partition to be free to move without friction so that the pressure of gases in both compartments is the same. Then total work done by the gases till the time they achieve equilibrium will be
(A) $250R$ (B) $200R$ (C) $100R$ (D) $-100R$

Paragraph for Questions 13-14

A spray gun is shown in the figure where a piston pushes air out of a nozzle. A thin tube of uniform cross section is connected to the nozzle. The other end of the tube is in a small liquid container. As the piston pushes air through the nozzle, the liquid from the container rises into the nozzle and is sprayed out. For the spray gun shown, the radii of the piston and the nozzle are 20 mm and 1 mm respectively. The upper end of the container is open to the atmosphere. (2014)



Q 13. If the piston is pushed at a speed of 5 mm/s, the air comes out of the nozzle with a speed of
(A) 0.1 m/s (B) 1 m/s (C) 2 m/s (D) 8 m/s

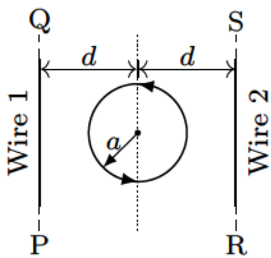
Q 14. If the density of air is ρ_a and that of the liquid is ρ_l, then for a given piston speed the rate (volume per unit time) at which the liquid is sprayed will be proportional to

(A) $\sqrt{\frac{\rho_a}{\rho_l}}$ (B) $\sqrt{\rho_a \rho_l}$ (C) $\sqrt{\frac{\rho_l}{\rho_a}}$ (D) ρ_l

Paragraph for Questions 15-16

The figure shows a circular loop of radius a with two long parallel wires (numbered 1 and 2) all in the plane of the paper. The distance of each wire from centre of the loop is d. The loop and the wires are carrying the same current I. The current in the loop is in counterclockwise direction if seen from above.

(2014)



Q 15. When $d \approx a$ but wires are not touching the loop, it is found that the net magnetic field on the axis of the loop is zero at a height h above the loop. In that case,

(A) current in wire 1 and wire 2 is the direction PQ and RS, respectively and $h \approx a$.

(B) current in wire 1 and wire 2 is the direction PQ and SR, respectively and $h \approx a$.

(C) current in wire 1 and wire 2 is the direction PQ and SR, respectively and $h \approx 1.2a$.

(D) current in wire 1 and wire 2 is the direction PQ and RS, respectively and $h \approx 1.2a$.

Q 16. Consider $d \gg a$, and the loop is rotated about its diameter parallel to the wires by 30° from the position shown in the figure. If the currents in the wires are in the opposite directions, the torque on the loop at its new position will be (assume that the net field due to the wires is constant over the loop)

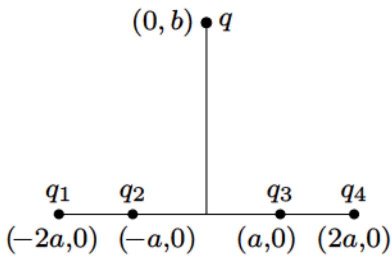
(A) $\frac{\mu_0 I^2 a^2}{d}$ (B) $\frac{\mu_0 I^2 a^2}{2d}$ (C) $\frac{\sqrt{3}\,\mu_0 I^2 a^2}{d}$ (D) $\frac{\sqrt{3}\,\mu_0 I^2 a^2}{2d}$

Matrix or Matching Type

This section contains 4 matching type questions, each having two matching columns. Choices for the correct combination of elements from column I and column II are given as option (A), (B), (C) and (D) out of which one is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Q 17. Four charges q_1, q_2, q_3 and q_4 of same magnitude are fixed along the x axis at $x = -2a, -a, +a$, and $+2a$, respectively. A positive charge q is placed on the positive y axis at a distance $b > 0$. Four options of the sign of these charges are given in *Column I*. The direction of the forces on the charge q is given in *Column II*. Match *Column I* with *Column II*.



Column I	Column II
(P) q_1, q_2, q_3, q_4 all positive	(1) $+x$
(Q) q_1, q_2 positive; q_3, q_4 negative	(2) $-x$
(R) q_1, q_4 positive; q_2, q_3 negative	(3) $+y$
(S) q_1, q_3 positive; q_2, q_4 negative	(4) $-y$

Q 18. Four combination of two thin lenses are given in *Column I*. The radius of curvature of all curved surfaces is r and refractive index of all the lenses is 1.5. Match lens combination in *Column I* with their focal length in *Column II*.

	Column I	Column II
(P)		(1) $2r$
(Q)		(2) $r/2$
(R)		(3) $-r$
(S)		(4) r

Q 19. A block of mass $m_1 = 1$ kg and another block of mass $m_2 = 2$ kg are placed together on an inclined plane with angle of inclination θ (see figure). Various values of θ are given in *Column I*. The coefficient of friction between the block m_1 and the plane is always zero. The coefficient of static and dynamic friction between the block m_2 and the plane are equal to $\mu = 0.3$. In *Column II* expressions for the friction on block m_2 are given. Match the correct expression of the friction in *Column II* with the angles given in *Column I*. The acceleration due to gravity is denoted by g. [Given, $\tan(5.5°) \approx 0.1$, $\tan(11.5°) \approx 0.2$, $\tan(16.5°) \approx 0.3$].

Column I	Column II
(P) $\theta = 5°$	(1) $m_2 g \sin\theta$
(Q) $\theta = 10°$	(2) $(m_1 + m_2) g \sin\theta$
(R) $\theta = 15°$	(3) $\mu m_2 g \cos\theta$
(S) $\theta = 20°$	(4) $\mu (m_1 + m_2) g \cos\theta$

Q 20. A person in a lift is holding a water jar, which has a small hole at the lower end of its side. When the lift is at rest, the water jet coming out of the hole hits the floor of the lift at a distance d of 1.2 m from the person. In the following, state of the lift's motion is given in *Column I* and the distance where the water jet hits the floor of the lift is given in *Column II*. Match the statements from *Column I* with those in *Column II*.

Column I	Column II
(P) Lift is accelerating vertically up.	(1) $d = 1.2$ m
(Q) Lift is accelerating vertically down with an acceleration less than the gravitational acceleration.	(2) $d > 1.2$ m
(R) Lift is moving vertically up with constant speed.	(3) $d < 1.2$ m
(S) Lift is falling freely.	(4) No water leaks out of the jar.

Answers

1. B
2. B
3. A
4. B
5. C
6. A
7. C
8. D
9. D
10. C
11. D
12. D
13. C
14. A
15. C
16. B
17. P$\mapsto$3, Q$\mapsto$1, R$\mapsto$4, S$\mapsto$2
18. P$\mapsto$2, Q$\mapsto$4, R$\mapsto$3, S$\mapsto$1
19. P$\mapsto$2, Q$\mapsto$2, R$\mapsto$3, S$\mapsto$3
20. P$\mapsto$1, Q$\mapsto$1, R$\mapsto$1, S$\mapsto$4

IIT JEE 2013

IIT JEE 2013 was a two stage examination (i) JEE Mains by CBSE and (ii) JEE Advanced by JAB. There were two papers in JEE Advanced namely, (Advanced) Paper 1 and (Advanced) Paper 2. Each of the papers has three separate parts for physics, chemistry and mathematics.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

(Advanced) Paper 1

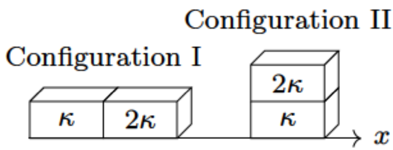
The physics part of the paper contains 20 questions. The questions are divided into three sections (1) single answer correct type (2) integer type and (3) multiple correct answers type.

One Option Correct

This section contains 10 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+2) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened

Q 1. Two rectangular blocks, having identical dimensions, can be arranged either in *configuration I* or in *configuration II* as shown in the figure. One of the blocks has thermal conductivity κ and the other 2κ. The temperature difference between the ends along the x-axis is the same in both the configurations. It takes 9 s to transport a certain amount of heat from the hot end to the cold end in the *configuration I*. The time to transport the same amount of heat in the *configuration II* is



(A) 2.0 s (B) 3.0 s (C) 4.5 s (D) 6.0 s

Q 2. Two non-reactive monatomic ideal gases have their atomic masses in the ratio 2 : 3. The ratio of their partial pressures, when enclosed in a vessel kept at a constant temperature is 4 : 3. The ratio of their densities is

(A) $1:4$ (B) $1:2$ (C) $6:9$ (D) $8:9$

Q 3. A particle of mass m is projected from the ground with an initial speed u_0 at an angle α with the horizontal. At the highest point of its trajectory, it makes a completely inelastic collision with another identical particle, which was thrown vertically upward from the ground with the same initial speed u_0. The angle that the composite system makes with the horizontal immediately after the collision is
(A) $\frac{\pi}{4}$ (B) $\frac{\pi}{4}+\alpha$ (C) $\frac{\pi}{2}-\alpha$ (D) $\frac{\pi}{2}$

Q 4. A pulse of light of duration 100 ns is absorbed completely by a small object initially at rest. Power of the pulse is 30 mW and the speed of light is 3×10^8 m/s. The final momentum of the object is

(A) 0.3×10^{-17} kg m/s (B) 1.0×10^{-17} kg m/s
(C) 3.0×10^{-17} kg m/s (D) 9.0×10^{-17} kg m/s

Q 5. In the Young's double slit experiment using a monochromatic light of wavelength λ, the path difference (in terms of an integer n) corresponding to any point having half the peak intensity is

(A) $(2n+1)\frac{\lambda}{2}$ (B) $(2n+1)\frac{\lambda}{4}$
(C) $(2n+1)\frac{\lambda}{8}$ (D) $(2n+1)\frac{\lambda}{16}$

Q 6. The image of an object, formed by a plano-convex lens at a distance of 8 m behind the lens, is real and is one-third the size of the object. The wavelength of light inside the lens is $2/3$ times the wavelength in free space. The radius of the curved surface of the lens is
(A) 1 m (B) 2 m (C) 3 m (D) 6 m

Q 7. One end of a horizontal thick copper wire of length $2L$ and radius $2R$ is welded to an end of another horizontal thin copper wire of length L and radius R. When the arrangement is stretched by applying forces at two ends, the ratio of the elongation in the thin wire to that in the thick wire is

(A) 0.25 (B) 0.5 (C) 2 (D) 4

Q 8. A ray of light travelling in the direction $\frac{1}{2}\left(\hat{\imath}+\sqrt{3}\,\hat{\jmath}\right)$ is incident on a plane mirror. After reflection, it travels along $\frac{1}{2}\left(\hat{\imath}-\sqrt{3}\,\hat{\jmath}\right)$. The angle of incidence is
(A) $30°$ (B) $45°$ (C) $60°$ (D) $75°$

Q 9. The diameter of a cylinder is measured using a Vernier calipers with no zero error. It is found that the zero of the Vernier scale lies between 5.10 cm and 5.15 cm of the main scale. The Vernier scale has 50 divisions equivalent to 2.45 cm. The 24^{th} division of the Vernier scale exactly coincides with one of the main scale divisions. The diameter of the cylinder is

(A) 5.112 cm (B) 5.124 cm

(C) 5.136 cm (D) 5.148 cm

Q 10. The work done on a particle of mass m by a force,

$$\vec{F} = K\left[\frac{x}{(x^2+y^2)^{3/2}}\hat{\imath} + \frac{y}{(x^2+y^2)^{3/2}}\hat{\jmath}\right]$$

(K being a constant of appropriate dimensions), when the particle is taken from the point $(a, 0)$ to the point $(0, a)$ along a circular path of radius a about the origin in the x-y plane is

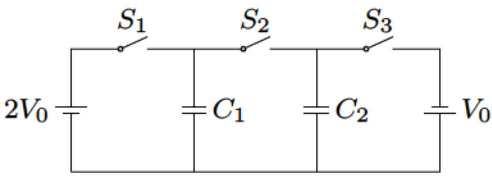
(A) $\frac{2K\pi}{a}$ (B) $\frac{K\pi}{a}$ (C) $\frac{K\pi}{2a}$ (D) 0

One or More Option(s) Correct

This section contains 5 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: −1 In all other cases

Q 11. In the circuit shown in figure, there are two parallel plate capacitors each of capacitance C. The switch S_1 is pressed first to fully charge the capacitor C_1 and then released. The switch S_2 is then pressed to charge the capacitor C_2. After some time, S_2 is released and then S_3 is pressed. After some time,



(A) the charge on the upper plate of C_1 is $2CV_0$
(B) the charge on the upper plate of C_1 is CV_0
(C) the charge on the upper plate of C_2 is 0
(D) the charge on the upper plate of C_2 is $-CV_0$

Q 12. Two non-conducting solid spheres of radii R and $2R$, having uniform volume charge densities ρ_1 and ρ_2 respectively, touch each other. The net electric field at a distance $2R$ from the centre of the smaller sphere, along the line joining the centres of the sphere, is zero. The ratio ρ_1/ρ_2 can be
(A) -4 (B) $-32/25$ (C) $32/25$ (D) 4

Q 13. A solid sphere of radius R and density ρ is attached to one end of a massless spring of force constant k. The other end of the spring is connected to another solid sphere of radius R and density 3ρ. The complete arrangement is placed in a liquid of density 2ρ and is allowed to reach equilibrium. The correct statement(s) is (are)

(A) the net elongation of the spring is $\frac{4\pi R^3 \rho g}{3k}$.
(B) the net elongation of the spring is $\frac{8\pi R^3 \rho g}{3k}$.
(C) the light sphere is partially submerged.
(D) the light sphere is completely submerged.

Q 14. A horizontal stretched string, fixed at two ends, is vibrating in its fifth harmonic according to the equation,

$$y(x,t) = (0.01\ \mathrm{m})\sin\left[(62.8\ \mathrm{m}^{-1})x\right]\cos\left[(628\ \mathrm{s}^{-1})t\right]$$

Assuming $\pi = 3.14$, the correct statement(s) is (are)

(A) The number of nodes is 5.

(B) The length of the string is 0.25 m.

(C) The maximum displacement of the midpoint of the string, from its equilibrium position is 0.01 m.

(D) The fundamental frequency is 100 Hz.

Q 15. A particle of mass m and positive charge q, moving with a constant velocity $\vec{u}_1 = 4\hat{\imath}$ m/s, enters a region of uniform static magnetic field normal to the x-y plane. The region of the magnetic field extends from $x = 0$ to $x = L$ for all values of y. After passing through this region, the particle emerges on the other side after 10 milliseconds with a velocity $\vec{u}_2 = 2\left(\sqrt{3}\hat{\imath} + \hat{\jmath}\right)$ m/s. The correct statement(s) is (are)

(A) The direction of the magnetic field is $-z$ direction.

(B) The direction of the magnetic field is $+z$ direction.

(C) The magnitude of the magnetic field is $\frac{50\pi m}{3q}$ units.

(D) The magnitude of the magnetic field is $\frac{100\pi m}{3q}$ units.

Integer Type

This section contains 5 questions. The answer to each question is a single digit integer ranging from 0 to 9, both inclusive. For each question, marks will be awarded in one of the following categories:

1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 16. A bob of mass m, suspended by a string of length l_1 is given a minimum velocity required to complete a full circle in the vertical plane. At the highest point, it collides elastically with another bob of mass m suspended by a string of length l_2, which is initially at rest. Both the strings are massless and inextensible. If the second bob, after collision acquires the minimum speed required to complete a full circle in the vertical plane, the ratio l_1/l_2 is ....

Q 17. A particle of mass 0.2 kg is moving in one dimension under a force that delivers a constant power 0.5 W to the particle. If the initial speed of the particle is zero, the speed (in m/s) after 5 s is ....

Q 18. The work functions of silver and sodium are 4.6 eV and 2.3 eV, respectively. The ratio of the slope of the stopping potential *versus* frequency plot for silver to that of sodium is . . . .

Q 19. A freshly prepared sample of a radioisotope of half-life 1386 s has activity 10^3 disintegrations per second. Given that $\ln 2 = 0.693$, the fraction of the initial number of nuclei (expressed in nearest integer percentage) that will decay in the first 80 s after preparation of the sample is ....

Q 20. A uniform circular disc of mass 50 kg and radius 0.4 m is rotating with an angular velocity of 10 rad/s about its own axis, which is vertical. Two uniform circular rings, each of mass 6.25 kg and radius 0.2 m, are gently placed symmetrically on the disc in such a manner that they are touching each other along the axis of the disc and are horizontal. Assume that the friction is large enough such that the rings are at rest relative to the disc and the system rotates about the original axis. The new angular velocity (in rad/s) of the system is . . . .

Answers

1. A
2. D
3. A
4. B
5. B
6. C
7. C
8. A
9. B
10. D
11. B, D
12. B, D
13. A, D
14. B, C
15. A, C
16. 5
17. 5
18. 1
19. 4
20. 8

(Advanced) Paper 2

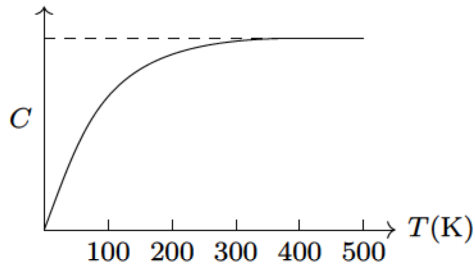
The physics part of the paper contains 20 questions. The questions are divided into three sections (1) multiple correct answers type (2) paragraph type and (3) matrix matching type.

One or More Option(s) Correct

This section contains 8 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is(are) correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 1. The figure shows variation of specific heat capacity (C) of a solid as a function of temperature (T). The temperature is increased continuously from 0 to 500 K at a constant rate. Ignoring any volume change, which of the following statement(s) is (are) correct to a reasonable approximation.



(A) the rate at which heat is absorbed in the range 0 – 100 K varies linearly with temperature T.
(B) heat absorbed in increasing the temperature from 0 – 100 K is less than the heat required for increasing the temperature from 400 – 500 K.
(C) there is no change in the rate of heat absorption in the range 400 – 500 K.
(D) the rate of heat absorption increases in the range 200 – 300 K.

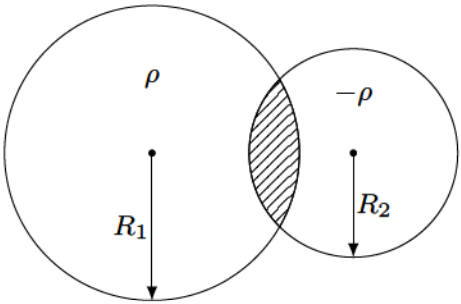
Q 2. The radius of the orbit of an electron in a Hydrogen-like atom is $4.5a_0$, where a_0 is the Bohr radius. Its orbital angular momentum is $\frac{3h}{2\pi}$. It is given that h is Planck constant and R is Rydberg constant. The possible wavelength(s), when the atom de-excites, is (are)

(A) $\frac{9}{32R}$ (B) $\frac{9}{16R}$ (C) $\frac{9}{5R}$ (D) $\frac{4}{3R}$

Q 3. Using the expression $2d\sin\theta = \lambda$, one calculates the value of d by measuring the corresponding angles θ in the range 0 to 90°. The wavelength λ is exactly known and the error in θ is constant for all values of θ. As θ increases from 0°,

(A) the absolute error in d remains constant.
(B) the absolute error in d increases.
(C) the fractional error in d remains constant.
(D) the fractional error in d decreases.

Q 4. Two non-conducting spheres of radii R_1 and R_2 and carrying uniform volume charge densities $+\rho$ and $-\rho$, respectively, are placed such that they partially overlap, as shown in the figure. At all points in the overlapping region,



(A) the electrostatic field is zero.
(B) the electrostatic potential is constant.
(C) the electrostatic field is constant in magnitude.
(D) the electrostatic field has same direction.

Q 5. A steady current I flows along an infinitely long hollow cylindrical conductor of radius R. The cylinder is placed coaxially inside an infinite solenoid of radius $2R$. The solenoid has n turns per unit length and carries a steady current I. Consider a point P at a distance r from the common axis. The correct statement(s) is (are)

(A) In the region $0 < r < R$, the magnetic field is non-zero.

(B) In the region $R < r < 2R$, the magnetic field is along the common axis.

(C) In the region $R < r < 2R$, the magnetic field is tangential to the circle of radius r centered on the axis.

(D) In the region $r > 2R$, the magnetic field is non-zero.

Q 6. Two vehicles, each moving with speed u on the same horizontal straight road, are approaching each other. Wind blows along the road with velocity w. One of these vehicles blows a whistle of frequency f_1. An observer in the other vehicle hears the frequency of the whistle to be f_2. The speed of sound in still air is v. The correct statement(s) is (are)

(A) If the wind blows from the observer to the source, $f_2 > f_1$.

(B) If the wind blows from the source to the observer, $f_2 > f_1$.

(C) If the wind blows from the observer to the source, $f_2 < f_1$.

(D) If the wind blows from the source to the observer, $f_2 < f_1$.

Q 7. Two bodies, each of mass M, are kept fixed with a separation $2L$. A particle of mass m is projected from the midpoint of the line joining their centres, perpendicular to the line. The gravitational constant is G. The correct statement(s) is (are)

(A) The minimal initial velocity of the mass m to escape the gravitational field of the two bodies is $4\sqrt{\frac{GM}{L}}$.

(B) The minimal initial velocity of the mass m to escape the gravitational field of the two bodies is $2\sqrt{\frac{GM}{L}}$.

(C) The minimal initial velocity of the mass m to escape the gravitational field of the two bodies is $\sqrt{\frac{2GM}{L}}$.

(D) The energy of the mass m remains constant.

Q 8. A particle of mass m is attached to one end of a massless spring of force constant k, lying on a frictionless horizontal plane. The other end of the spring is fixed. The particle starts moving horizontally from its equilibrium position at $t = 0$ with an initial velocity u_0. When the speed of the particle is $0.5u_0$, it collides elastically with a rigid wall. After this collision,

(A) the speed of the particle when it returns to its equilibrium position is u_0.

(B) the time at which the particle passes through the equilibrium position for the first time is $t = \pi\sqrt{\frac{m}{k}}$.

(C) the time at which the maximum compression of the spring occurs is $t = \frac{4\pi}{3}\sqrt{\frac{m}{k}}$.

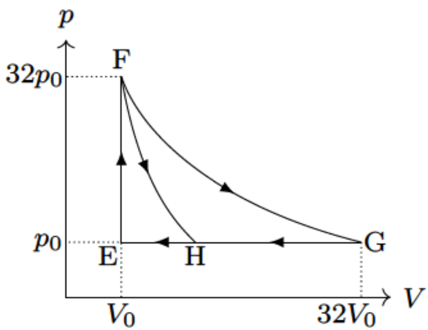
(D) the time at which the particle passes through the equilibrium position for the second time is $t = \frac{5\pi}{3}\sqrt{\frac{m}{k}}$.

Matrix or Matching Type

This section contains 4 matching type questions, each having two matching columns. Choices for the correct combination of elements from column I and column II are given as option (A), (B), (C) and (D) out of which one is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Q 9. One mole of a monatomic ideal gas is taken along two cyclic processes $E \to F \to G \to E$ and $E \to F \to H \to E$ as shown in the p-V diagram. The processes involved are purely isochoric, isobaric, isothermal or adiabatic. Match the paths in *Column I* with the magnitudes of the work done in *Column II*.



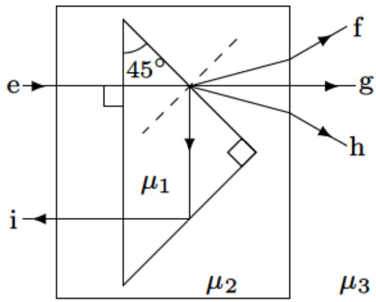
Column I	Column II
(P) G→ E	(1) $160 p_0 V_0 \ln 2$
(Q) G→ H	(2) $36 p_0 V_0$
(R) F→ H	(3) $24 p_0 V_0$
(S) F→ G	(4) $31 p_0 V_0$

Q 10. Match *Column I* of the nuclear processes with *Column II* containing parent nucleus and one of the end products of each process,

Column I	Column II
(P) Alpha decay	(1) $^{15}_{8}\text{O} \rightarrow {}^{15}_{7}\text{N} + \ldots$
(Q) β^+ decay	(2) $^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + \ldots$
(R) Fission	(3) $^{185}_{83}\text{Bi} \rightarrow {}^{184}_{82}\text{Pb} + \ldots$
(S) Proton Emission	(4) $^{239}_{94}\text{Pu} \rightarrow {}^{140}_{57}\text{La} + \ldots$

Q 11. A right angled prism of refractive index μ_1 is placed in a rectangular block of refractive index μ_2, which is surrounded by a medium of refractive index μ_3, as shown in the figure. A ray of light 'e' enters the rectangular block at normal incidence. Depending upon the relationships between μ_1, μ_2 and μ_3, it takes one of the four possible paths 'ef', 'eg', 'eh', or 'ei'.

Match the paths in *Column I* with conditions of refractive indices in *Column II*.



Column I	Column II
(p) $e \to f$	(1) $\mu_1 > \sqrt{2}\,\mu_2$
(q) $e \to g$	(2) $\mu_2 > \mu_1$ and $\mu_2 > \mu_3$
(r) $e \to h$	(3) $\mu_1 = \mu_2$
(s) $e \to i$	(4) $\mu_2 < \mu_1 < \sqrt{2}\,\mu_2$ and $\mu_2 > \mu_3$

Q 12. Match the physical quantities given in *List I* to their dimensions in *List II*.

Column I	Column II
(P) Boltzmann constant	(1) $[ML^2T^{-1}]$
(Q) Coefficient of viscosity	(2) $[ML^{-1}T^{-1}]$
(R) Planck constant	(3) $[MLT^{-3}K^{-1}]$
(S) Thermal conductivity	(4) $[ML^2T^{-2}K^{-1}]$

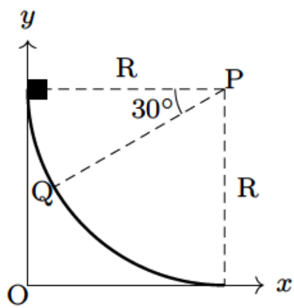
Paragraph Type

This section contains 8 question based on four paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 13-14

A small block of mass 1 kg is released from rest at the top of a rough track. The track is a circular arc of radius 40 m. The block slides along the track without toppling and frictional force acts on it in the direction opposite to the instantaneous velocity. The work done in overcoming the friction up to the point Q, as shown in the figure, is 150 J. [Take $g = 10\ \text{m/s}^2$.] **(2013)**



Q 13. The speed of the block when it reaches the point Q is
(A) 5 m/s (B) 10 m/s (C) $10\sqrt{3}$ m/s (D) 20 m/s

Q 14. The magnitude of the normal reaction that acts on the block at the point Q is
(A) 7.5 N (B) 8.6 N (C) 11.5 N (D) 22.5 N

Paragraph for Questions 15-16

A thermal power plant produces electric power of 600 kW at 4000 V, which is to be transported to a place 20 km away from the power plant for consumers' usage. It can be transported either directly with a cable of large current carrying capacity or by using a combination of step-up and step-down transformers at the two ends. The drawback of the direct transmission is the large energy dissipation. In the method using transformers, the dissipation is much smaller. In this method, a step-up transformer is used at the plant side so that the current is reduced to a smaller value. At the consumers' end, a step-down transformer is used to supply power to the consumers at the specified lower voltage. It is reasonable to assume that the power cable is purely resistive and the transformers are ideal with a power factor unity. All the currents and voltages mentioned are *rms* values. **(2013)**

Q 15. If the direct transmission method with a cable of resistance $0.4\,\Omega/\text{km}$ is used, the power dissipation (in %) during transmission is
(A) 20 (B) 30 (C) 40 (D) 50

Q 16. In the method using the transformers, assume that the ratio of the number of turns in the primary to that in the secondary in the step-up transformer is $1 : 10$. If the power to the consumers has to be supplied at 200 V, the ratio of the number of turns in the primary to that in the secondary in the step-down transformer is

(A) $200 : 1$ (B) $150 : 1$ (C) $100 : 1$ (D) $50 : 1$

Paragraph for Questions 17-18

A point charge Q is moving in a circular orbit of radius R in the x-y plane with an angular velocity ω. This can be considered as equivalent to a loop carrying a steady current $\frac{Q\omega}{2\pi}$. A uniform magnetic field along the positive z-axis is now switched on, which increases at a constant rate from 0 to B in one second. Assume that the radius of the orbit remains constant. The application of the magnetic field induces an *emf* in the orbit. The induced *emf* is defined as the work done by an induced electric field in moving a unit positive charge around a closed loop. It is known that, for an orbiting charge, the magnetic dipole moment is proportional to the angular momentum with a proportionality constant γ. (2013)

Q 17. The magnitude of the induced electric field in the orbit at any instant of time during the time interval of the magnetic field change is
(A) $BR/4$ (B) $BR/2$ (C) BR (D) $2BR$

Q 18. The change in the magnetic dipole moment associated with the orbit, at the end of the time interval of the magnetic field change is

(A) $-\gamma BQR^2$ (B) $-\gamma \frac{BQR^2}{2}$

(C) $\gamma \frac{BQR^2}{2}$ (D) γBQR^2

Paragraph for Questions 19-20

The mass of a nucleus ${}_Z^AX$ is less than the sum of the masses of $(A-Z)$ number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of masses m_1 and m_2 only if $(m_1 + m_2) < M$. Also two light nuclei of masses m_3 and m_4 can undergo complete fusion and form a heavy nucleus of mass M' only if $(m_3+m_4) > M'$. The masses of some neutral atoms are given in table below: (2013)

${}_1^1\mathrm{H}$	: 1.007825 u ,	${}_1^2\mathrm{H}$	: 2.014102 u
${}_1^3\mathrm{H}$	: 3.016050 u ,	${}_2^4\mathrm{He}$	: 4.002603 u
${}_3^6\mathrm{Li}$	: 6.015123 u ,	${}_3^7\mathrm{Li}$	: 7.016004 u
${}_{30}^{70}\mathrm{Zn}$	: 69.925325 u ,	${}_{34}^{82}\mathrm{Se}$	: 81.916709 u
${}_{64}^{152}\mathrm{Gd}$	: 151.919803 u ,	${}_{82}^{206}\mathrm{Pb}$	: 205.974455 u
${}_{83}^{209}\mathrm{Bi}$	: 208.980388 u ,	${}_{84}^{210}\mathrm{Po}$	: 209.982876 u

[Given 1 u = 932 MeV/c^2.]

Q 19. The correct statement is

(A) The nucleus $^{6}_{3}$Li can emit an alpha particle.

(B) The nucleus $^{210}_{84}$Po can emit a proton.

(C) Deuteron and alpha particle can undergo complete fusion.

(D) The nuclei $^{70}_{30}$Zn and $^{82}_{34}$Se can undergo complete fusion.

Q 20. The kinetic energy (in keV) of the alpha particle, when the nucleus $^{210}_{84}Po$ at rest undergoes alpha decay, is

(A) 5319 (B) 5422 (C) 5707 (D) 5818

Answers

1. B, C, D
2. A, C
3. D
4. C, D
5. A, D
6. A, B
7. B, D
8. A, D
9. $P \mapsto 4$, $Q \mapsto 3$, $R \mapsto 2$, $S \mapsto 1$
10. $P \mapsto 2$, $Q \mapsto 1$, $R \mapsto 4$, $S \mapsto 3$
11. $p \mapsto 2$, $q \mapsto 3$, $r \mapsto 4$, $s \mapsto 1$
12. $P \mapsto 4$, $Q \mapsto 2$, $R \mapsto 1$, $S \mapsto 3$
13. B
14. A
15. B
16. A
17. B
18. B
19. C
20. A

IIT JEE 2012

IIT JEE 2012 was a single stage examination of two papers, Paper 1 and Paper 2, each of three hours duration. Each of the papers has three separate sections of physics, chemistry and mathematics. All questions were of objective type, designed to test comprehension, reasoning and analytical ability of the candidate.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper 1

The physics part of the paper contains 20 questions. The questions are divided into three sections (1) single correct answer type (2) multiple correct answers type and (3) integer type.

One Option Correct

This section contains 10 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

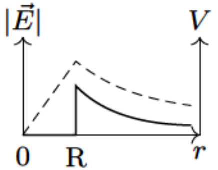
1. Full Marks: (+2) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

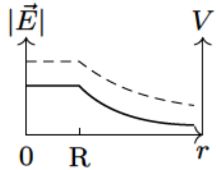
Q 1. Three very large plates of same area are kept parallel and close to each other. They are considered as ideal black surfaces and have very large thermal conductivity. The first and third plates are maintained at temperatures $2T$ and $3T$, respectively. The temperature of the middle (i.e. second) plate under steady state condition is

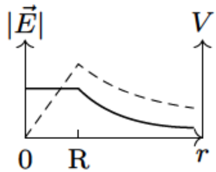
(A) $\left(\frac{65}{2}\right)^{1/4}T$ (B) $\left(\frac{97}{4}\right)^{1/4}T$

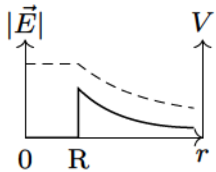
(C) $\left(\frac{97}{2}\right)^{1/4}T$ (D) $(97)^{1/4}T$

Q 2. Consider a thin spherical shell of radius R with its centre at origin, carrying uniform positive surface charge density. The variation of the magnitude of the electric field $|\vec{E}(r)|$ and the electric potential $V(r)$ with distance r from the centre, is best represented by the graph?

(A) 

(B) 

(C) 

(D) 

Q 3. In the determination of Young's modulus $\left(Y = \frac{4MLg}{\pi l d^2}\right)$ by using Searle's method, a wire of length $L = 2$ m and diameter $d = 0.5$ mm is used. For a load $M = 2.5$ kg, an extension $l = 0.25$ mm in the length of wire is observed. Quantities d and l are measured using screw gauge and micrometer, respectively. They have same pitch of 0.5 mm. The number of divisions on their circular scale is 100. The contributions to the maximum probable error of the Y measurement,

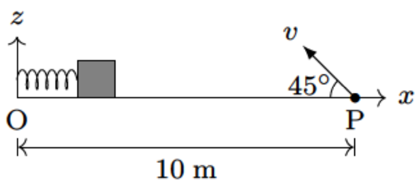
(A) due to the error in the measurements of d and l are the same.

(B) due to the error in the measurement of d is twice that due to the error in the measurement of l.

(C) due to the error in the measurement of l is twice that due to the error in the measurement of d.

(D) due to the error in the measurement of d is four times that due to the error in measurement of l.

Q 4. A small block is connected to one end of a massless spring of unstretched length 4.9 m. The other end of the spring (see figure) is fixed. The system lies on horizontal frictionless surface. The block is stretched by 0.2 m and released from rest at $t = 0$. It then executes SHM with angular frequency $\omega = \pi/3$ rad/s. Simultaneously, at $t = 0$, a small pebble is projected with speed v from point P at an angle of 45° as shown in the figure. Point P is at a distance of 10 m from O. If the pebble hits the block at $t = 1$ s, the value of v is [Take $g = 10$ m/s^2.]

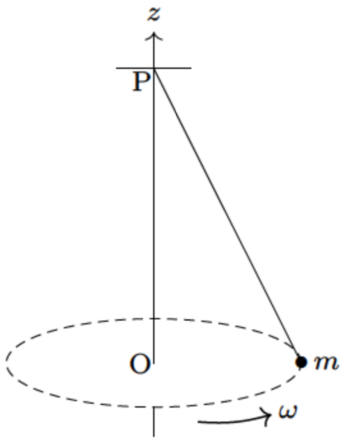


(A) $\sqrt{50}$ m/s (B) $\sqrt{51}$ m/s
(C) $\sqrt{52}$ m/s (D) $\sqrt{53}$ m/s

Q 5. Young's double slit experiment is carried out by using green, red and blue light, one color at a time. The fringe width recorded are β_G, β_R, and β_B, respectively. Then,

(A) $\beta_G > \beta_B > \beta_R$ (B) $\beta_B > \beta_G > \beta_R$
(C) $\beta_R > \beta_B > \beta_G$ (D) $\beta_R > \beta_G > \beta_B$

Q 6. A small mass m is attached to a massless string whose other end is fixed at P as shown in the figure. The mass is undergoing circular motion in the x-y plane with centre at O and constant angular speed ω. If the angular momentum of the system, calculated about O and P are denoted by $\vec{L}_O$ and $\vec{L}_P$, respectively, then,



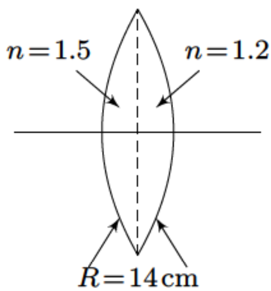
(A) $\vec{L}_O$ and $\vec{L}_P$ do not vary with time.
(B) $\vec{L}_O$ varies with time while $\vec{L}_P$ remains constant.
(C) $\vec{L}_O$ remains constant while $\vec{L}_P$ varies with time.
(D) $\vec{L}_O$ and $\vec{L}_P$ both vary with time.

Q 7. A mixture of 2 mol of helium gas (atomic mass=4 u) and 1 mol of argon gas (atomic mass=40 u) is kept at 300 K in a container. The ratio of *rms* speed $\frac{v_{rms}(\text{helium})}{v_{rms}(\text{argon})}$ is
(A) 0.32 (B) 0.45 (C) 2.24 (D) 3.16

Q 8. Two large vertical and parallel metal plates having a separation of 1 cm are connected to a DC voltage source of potential difference X. A proton is released at rest midway between the two plates. It is found to move at 45° to the vertical just after release. Then X is nearly

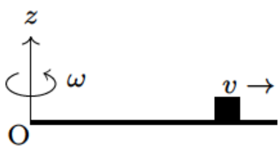
(A) 10^{-5} V (B) 10^{-7} V (C) 10^{-9} V (D) 10^{-10} V

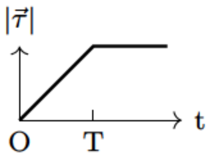
Q 9. A biconvex lens is formed with two thin plano-convex lenses as shown in the figure. Refractive index n of the first lens is 1.5 and that of the second lens is 1.2. Both the curved surfaces are of the same radius of curvature $R = 14$ cm. For this biconvex lens, for an object distance of 40 cm, the image distance will be

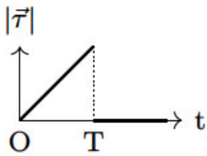


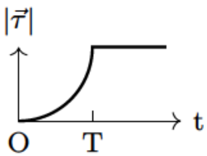
(A) -280 cm (B) 40 cm (C) 21.5 cm (D) 13.3 cm

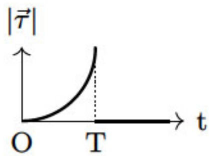
Q 10. A thin uniform rod, pivoted at O, is rotating in horizontal plane with constant speed ω, as shown in the figure. At time $t = 0$, a small insect starts from O and moves with constant speed v with respect to the rod towards the other end. It reaches the end of the rod at $t = T$ and stops. The angular speed of the system remains ω throughout. The magnitude of torque ($|\vec{\tau}|$) on the system about O, as a function of time is best represented by which plot?



(A) 

(B) 

(C) 

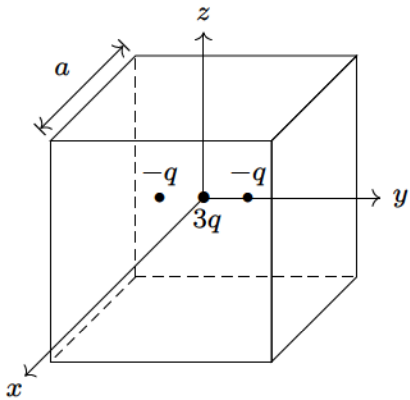
(D) 

One or More Option(s) Correct

This section contains 5 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened

Q 11. A cubical region of side a has it centre at the origin. It encloses three fixed point charges $-q$ at $(0, -a/4, 0)$ $+3q$ at $(0, 0, 0)$ and $-q$ at $(0, a/4, 0)$. Choose the correct option(s).



(A) The net electric flux crossing the plane $x = +a/2$ is equal to the net electric flux crossing the plane $x = -a/2$.

(B) The net electric flux crossing the plane $y = +a/2$ is more than the net electric flux crossing the plane $y = -a/2$.

(C) The net electric flux crossing the entire region is q/ϵ_0.

(D) The net electric flux crossing the plane $z = +a/2$ is equal to the net electric flux crossing the plane $x = +a/2$.

Q 12. A person blows into open-end of a long pipe. As a result, a high pressure pulse of air travels down the pipe. When this pulse reaches the other end of pipe,

(A) a high pressure pulse starts travelling up the pipe, if the other end of pipe is open.

(B) a low pressure pulse starts travelling up the pipe, if the other end of pipe is open.

(C) a low pressure pulse starts travelling up the pipe, if the other end of pipe is closed.

(D) a high pressure pulse starts travelling up the pipe if the other end of pipe is closed.

Q 13. Consider the motion of a positive charge in a region where there are simultaneous uniform electric and magnetic fields $\vec{E} = E_0\hat{\jmath}$ and $\vec{B} = B_0\hat{\jmath}$. At time $t = 0$, this charge has velocity v in the x-y plane making an angle θ with the x axis. Which of the following option(s) is (are) correct for $t > 0$?

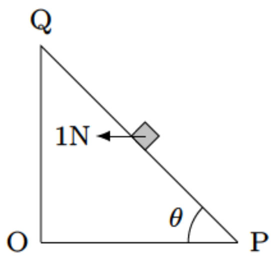
(A) If $\theta = 0$, the charge moves in a circular path in the x-z plane.

(B) If $\theta = 0$, the charge undergoes helical motion with constant pitch along y axis.

(C) If $\theta = 10°$, the charge undergoes helical motion with its pitch increasing with time, along the y axis.

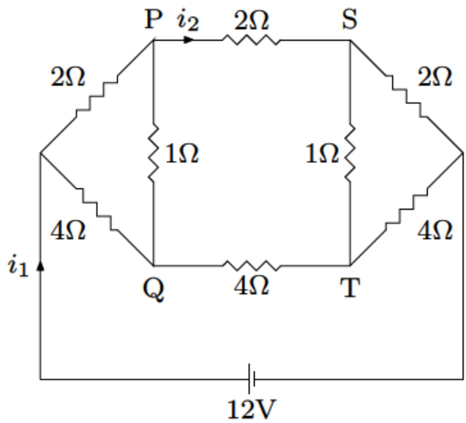
(D) If $\theta = 90°$, the charge undergoes linear but accelerated motion along y axis.

Q 14. A small block of mass 0.1 kg lies on a fixed inclined plane PQ which makes an angle θ with the horizontal. A horizontal force of 1 N acts on the block through its centre of mass as shown in the figure. The block remains stationary if [Take $g = 10\ \mathrm{m/s^2}$.]



(A) $\theta = 45°$
(B) $\theta > 45°$ and frictional force acts on the block towards P
(C) $\theta > 45°$ and frictional force acts on the block towards Q
(D) $\theta < 45°$ and frictional force acts on the block towards Q

Q 15. For the resistance network shown in the figure, choose the correct option(s),



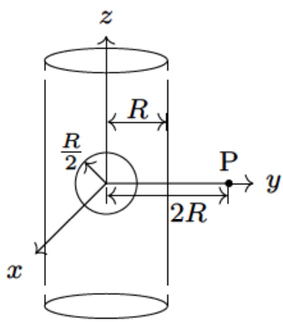
(A) The current through PQ is zero.
(B) $i_1 = 3$ A
(C) The potential at S is less than that at Q.
(D) $i_2 = 2$ A

Integer Type

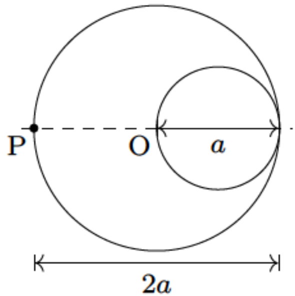
This section contains 5 questions. The answer to each question in this section is a single digit integer ranging from 0 to 9, both inclusive. Marking scheme is:

1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

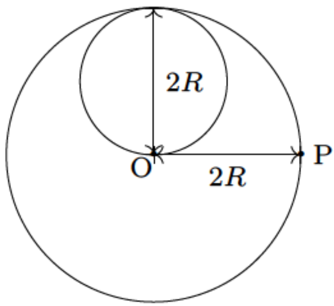
Q 16. An infinitely long solid cylinder of radius R has a uniform charge density ρ. It has a spherical cavity of radius $R/2$ with its centre on the axis of cylinder, as shown in the figure. The magnitude of electric field at point P, which is at a distance $2R$ from the axis of the cylinder, is given by the expression $\frac{23\rho R}{16k\epsilon_0}$. The value of k is ....



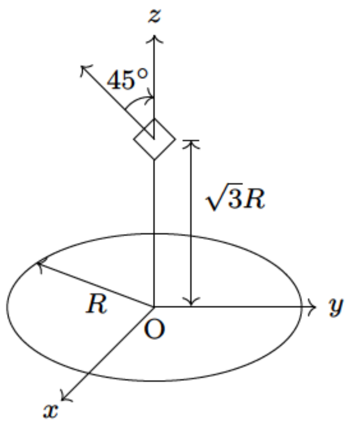
Q 17. A cylindrical cavity of diameter a exist inside a cylinder of diameter $2a$ as shown in the figure. Both the cylinder and cavity are infinitely long. A uniform current density J flows along the length. If the magnitude of magnetic field at point P is given by $\frac{N}{12}\mu_0 aJ$, then the value of N is ....



Q 18. A lamina is made by removing a small disc of diameter $2R$ from a bigger disc of uniform mass density and radius $2R$ as shown in the figure. The moment of inertia of this lamina about axes passing through O and P is I_O and I_P, respectively. Both these axes are perpendicular to the plane of lamina. The ratio $\frac{I_P}{I_O}$ to the nearest integer is ....



Q 19. A circular wire loop of radius R is placed in x-y plane centered at the origin O. A square loop of side a ($a \ll R$) having two turns is placed with its centre at $z = \sqrt{3}R$ along the axis of the circular wire loop, as shown in the figure. The plane of the loop makes an angle of 45° with respect to z-axis. If the mutual inductance between the loops is given by $\frac{\mu_0 a^2}{2^{(p/2)} R}$, then the value of p is ....



Q 20. A proton is fired from very far away towards a nucleus of charge $Q = 120e$, where e is electronic charge. It makes a closest approach of 10 fm to the nucleus. The de-Broglie wavelength (in units of fm) of proton at its start is .... [Take the proton mass $m_p = 5/3 \times 10^{-27}$ kg, $h/e = 4.2 \times 10^{-15}$ J s/C, $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9$ m/F, 1 fm $= 10^{-15}$ m.]

Answers

1. C
2. D
3. A
4. A
5. D
6. C
7. D
8. C
9. B
10. B
11. A, C, D
12. B, D
13. C, D
14. A, C
15. A, B, C, D
16. 6
17. 5
18. 3
19. 7
20. 7

Paper 2

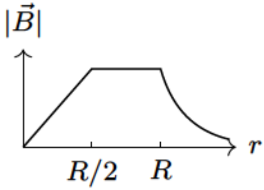
The physics part of the paper contains 20 questions. The questions are divided into three sections (1) single correct answer type (2) multiple correct answers type and (3) paragraph type.

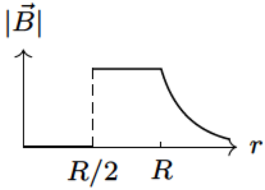
One Option Correct

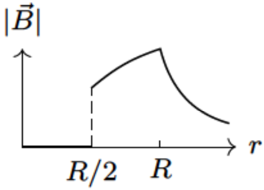
This section contains 8 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

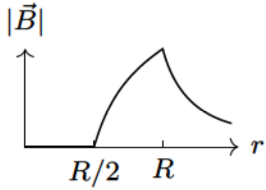
1. Full Marks: (+2) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 1. An infinitely long hollow conducting cylinder with inner radius $R/2$ and outer radius R carries a uniform current density along its length. The magnitude of the magnetic field, $|\vec{B}|$ as a function of the radial distance r from the axis is best represented by

(A) 

(B) 

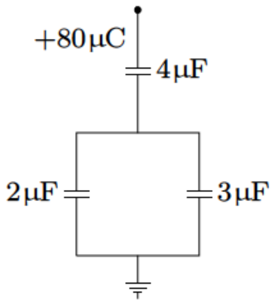
(C) 

(D) 

Q 2. A thin uniform cylindrical shell, closed at both ends, is partially filled with water. It is floating vertically in water in half-submerged state. If ρ_c is the relative density of the material of the shell with respect to water, then the correct statement is that the shell is

(A) more than half-filled if ρ_c is less than 0.5.
(B) more than half-filled if ρ_c is more than 1.0.
(C) half-filled if ρ_c is more than 0.5.
(D) less than half-filled if ρ_c is less than 0.5.

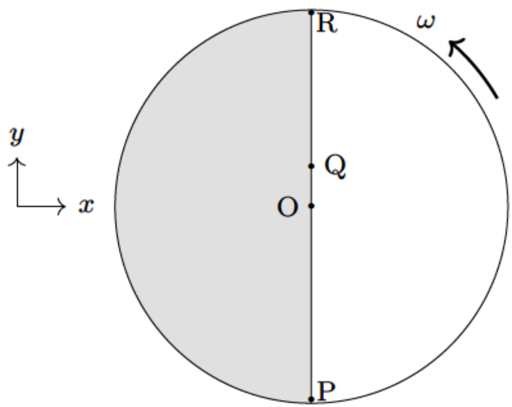
Q 3. In the given circuit, a charge of +80 μC is given to the upper plate of the 4 μF capacitor. Then in the steady state, the charge on the upper plate of the 3 μF capacitor is



(A) +32 μC (B) +40 μC (C) +48 μC (D) +80 μC

Q 4. Two moles of ideal helium gas are in rubber balloon at 30 °C. The balloon is fully expandable and can be assumed to require no energy in its expansion. The temperature of the gas in the balloon is slowly changed to 35 °C. The amount of heat required in raising the temperature is nearly [Take $R = 8.31$ J/mol K.]
(A) 62 J (B) 104 J (C) 124 J (D) 208 J

Q 5. Consider a disc rotating in the horizontal plane with constant angular speed ω about its centre O. The disc has a shaded region on one side of the diameter and an unshaded region on the other side as shown in the figure. When the disc is in the orientation as shown, two pebbles P and Q are simultaneously projected at an angle towards R. The velocity of projection is in the y-z plane and is same for both pebbles with respect to the disc. Assume that (i) they land back on the disc before the disc has completed 1/8 rotation, (ii) their range is less than half the disc radius, and (iii) ω is constant throughout. Then,



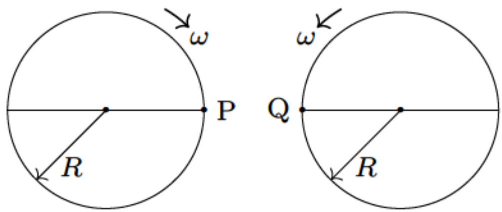
(A) P lands in the shaded region and Q in the unshaded region.

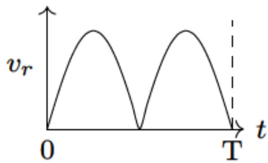
(B) P lands in the unshaded region and Q in the shaded region.
(C) Both P and Q land in the unshaded region.
(D) Both P and Q land in the shaded region.

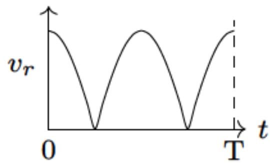
Q 6. A student is performing the experiment of resonance column. The diameter of the column tube is 4 cm. The frequency of the tuning fork is 512 Hz. The air temperature is 38 °C at which the speed of sound is 336 m/s. The zero of meter scale coincides with the top end of the resonance column tube. When the first resonance occurs, the reading of the water level in the column is

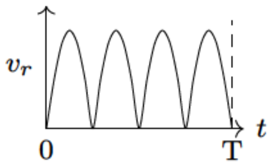
(A) 14.0 cm (B) 15.2 cm (C) 16.4 cm (D) 17.6 cm

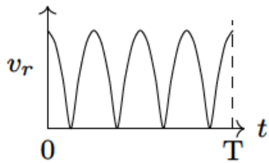
Q 7. Two identical discs of same radius R are rotating about their axes in opposite directions with the constant angular speed ω. The discs are in the same horizontal plane. At time $t = 0$, the point P and Q are facing each other as shown in the figure. The relative speed between the two points P and Q is v_r. In one time period (T) of rotation of the discs, v_r as a function of time is best represented by



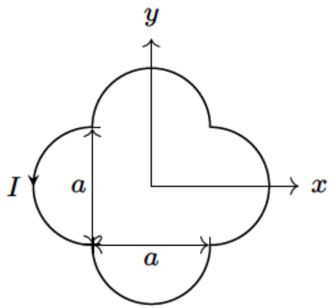
(A) 

(B) 

(C) 

(D) 

Q 8. A loop carrying current I lies in the x-y plane as shown in the figure. The unit vector $\hat{k}$ is coming out of the plane of the paper. The magnetic moment of the current loop is



(A) $a^2 I\hat{k}$ (B) $\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$

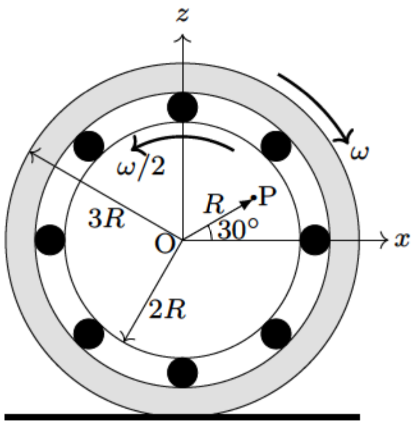
(C) $-\left(\frac{\pi}{2}+1\right)a^2 I\hat{k}$ (D) $(2\pi+1)\,a^2 I\hat{k}$

One or More Option(s) Correct

This section contains 6 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) In all other cases

Q 9. The figure shows a system consisting of (i) a ring of outer radius $3R$ rolling clockwise without slipping on a horizontal surface with angular speed ω and (ii) an inner disc of radius $2R$ rotating anti-clockwise with angular speed $\omega/2$. The ring and disc are separated by frictionless ball bearings. The system is in the x-z plane. The point P on the inner disc is at a distance R from the origin, where OP makes an angle of $30°$ with the horizontal. Then with respect to the horizontal surface,



(A) the point O has a linear velocity $3R\omega\hat{\imath}$.

(B) the point P has a linear velocity $\frac{11}{4}R\omega\hat{\imath} + \frac{\sqrt{3}}{4}R\omega\hat{k}$.

(C) the point P has a linear velocity $\frac{13}{4}R\omega\hat{\imath} - \frac{\sqrt{3}}{4}R\omega\hat{k}$.

(D) the point P has a linear velocity $\left(3 - \frac{\sqrt{3}}{4}\right) R\omega\hat{\imath} + \frac{1}{4}R\omega\hat{k}$.

Q 10. Two spherical planets P and Q have the same uniform density ρ, masses M_P and M_Q, and surface areas A and $4A$, respectively. A spherical planet R has uniform density ρ and its mass is $(M_P + M_Q)$. The escape velocities from the planets P, Q and R, are V_P, V_Q and V_R, respectively. Then,

(A) $V_Q > V_R > V_P$ (B) $V_R > V_Q > V_P$

(C) $V_R/V_P = 3$ (D) $V_P/V_Q = 1/2$

Q 11. Two solid cylinders P and Q of same mass and same radius start rolling down a fixed inclined plane from the same height at the same time. Cylinder P has most of its mass concentrated near its surface, while Q has most of its mass concentrated near the axis. Which statement(s) is (are) correct?

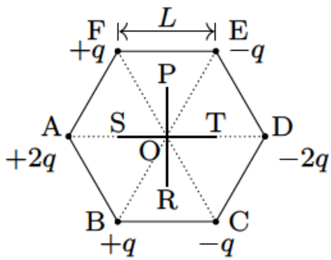
(A) Both cylinders P and Q reach the ground at the same time.

(B) Cylinder P has larger linear acceleration than cylinder Q.

(C) Both cylinders reach the ground with same translational kinetic energy.

(D) Cylinder Q reaches the ground with larger angular speed.

Q 12. Six point charges are kept at the vertices of a regular hexagon of side L and centre O, as shown in the figure. Given that $K = \frac{1}{4\pi\epsilon_0}\frac{q}{L^2}$, which of the following statement(s) is (are) correct?



(A) The electric field at O is $6K$ along OD.
(B) The potential at O is zero.
(C) The potential at all points on the line PR is same.
(D) The potential at all points on the line ST is same.

Q 13. A current carrying infinitely long wire is kept along the diameter of a circular wire loop, without touching it. The correct statement(s) is (are)

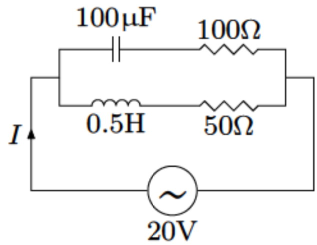
(A) The *emf* induced in the loop is zero if the current is constant.

(B) The *emf* induced in the loop is finite if the current is constant.

(C) The *emf* induced in the loop is zero if the current decreases at a steady rate.

(D) The *emf* induced in the loop is finite if the current decreases at a steady rate.

Q 14. In the given circuit, the AC source has $\omega = 100$ rad/s. Considering the inductor and capacitor to be ideal, the correct choice(s) is (are)



(A) The current through the circuit, I is 0.3 A.
(B) The current through the circuit, I is $0.3\sqrt{2}$ A.
(C) The voltage across 100 Ω resistor = $10\sqrt{2}$ V.
(D) The voltage across 50 Ω resistor = 10 V.

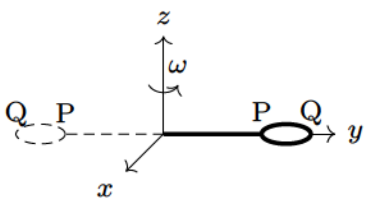
Paragraph Type

This section contains 6 questions related to three paragraphs with two questions on each paragraph. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

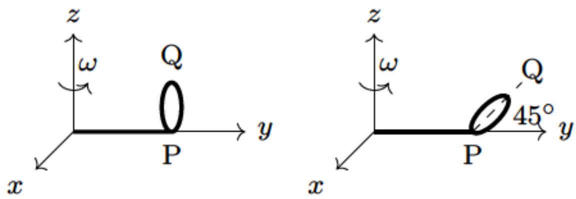
Paragraph for Questions 15-16

The general motion of a rigid body can be considered to be a combination of (i) a motion of its centre of mass about an axis, and (ii) its motion about an instantaneous axis passing through the centre of mass. These axes need not be stationary. Consider, for example, a thin uniform disc welded (rigidly fixed) horizontally at its rim to a massless stick, as shown in the figure. When the disc-stick system is rotated about the origin on a horizontal frictionless plane with angular speed ω, the motion at any instant can be taken as a combination of (i) a rotation of the centre of mass of the disc about the z-axis, and (ii) a rotation of the disc through an instantaneous vertical axis passing through its centre of mass (as is seen from the changed orientation of points P and Q). Both these motions have the same angular speed ω in this case.



Now consider two similar systems as shown in the figure: *Case (a)* the disc with its face vertical and parallel to x-z plane; *Case (b)* the disc with its face making

an angle of 45° with x-y plane and its horizontal diameter parallel to x-axis. In both the cases, the disc is welded at point P, and the systems are rotated with constant angular speed ω about the z-axis. (2012)



Q 15. Which of the following statements about the instantaneous axis (passing through the centre of mass) is correct?

(A) It is vertical for both the case (a) and (b).

(B) It is vertical for case (a); and is at 45° to the x-z plane and lies in the plane of the disc for case (b).

(C) It is horizontal in case (a); and is at 45° to the x-z plane and is normal to the plane of the disc for case (b).

(D) It is vertical for case (a); and is at 45° to the x-z plane and is normal to the plane of the disc for case (b).

Q 16. Which of the following statements regarding the angular speed about the instantaneous axis (passing through the centre of mass) is correct?

(A) It is $\sqrt{2}\omega$ for both the cases.

(B) It is ω for case (a); and $\frac{\omega}{\sqrt{2}}$ for case (b).

(C) It is ω for case (a); and $\sqrt{2}\omega$ for case (b).

(D) It is ω for both the cases.

Paragraph for Questions 17-18

The β-decay process, discovered around 1900, is basically the decay of a neutron (n). In the laboratory, a proton (p) and an electron (e^-) are observed as the decay product of the neutron. Therefore, considering the decay of a neutron as a two body decay process, it was predicted theoretically that the kinetic energy of the electron should be constant. But experimentally, it was observed that the electron kinetic energy has a continuous spectrum. Considering a three-body decay process i.e., $n \to p + e^- + \bar{\nu}_e$, around 1930, Pauli explained the observed electron energy spectrum. Assuming the antineutrino ($\bar{\nu}_e$) to be massless and possessing negligible energy, and the neutron to be at rest, momentum and energy conservation principles are applied. From this calculation, the maximum kinetic energy of the electron is 0.8×10^6 eV. The kinetic energy carried by the proton is only the recoil energy. **(2012)**

Q 17. What is the maximum energy of the anti-neutrino?

(A) Zero.

(B) Much less than 0.8×10^6 eV.

(C) Nearly 0.8×10^6 eV.

(D) Much larger than 0.8×10^6 eV.

Q 18. If the anti-neutrino had a mass of 3 $\mathrm{eV/c^2}$ (where c is the speed of light) instead of zero mass, what should be the range of the kinetic energy, K, of the electron?

(A) $0 \leq K \leq 0.8 \times 10^6$ eV
(B) $3.0 \text{ eV} \leq K \leq 0.8 \times 10^6$ eV
(C) $3.0 \text{ eV} \leq K < 0.8 \times 10^6$ eV
(D) $0 \leq K < 0.8 \times 10^6$ eV

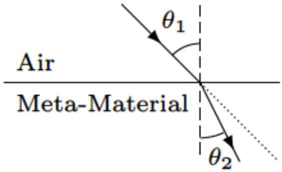
Paragraph for Questions 19-20

Most materials have refractive index, $n > 1$. So, when a light ray from air enters a naturally occurring material, then by Snell's law, $\frac{\sin\theta_1}{\sin\theta_2} = \frac{n_2}{n_1}$, it is understood that the refracted ray bends towards the normal. But it never emerges on the same side of the normal as the incident ray. According to electromagnetism, the refractive index of the medium is given by the relation, $n = \frac{c}{v} = \pm\sqrt{\epsilon_r \mu_r}$, where c is the speed of electromagnetic waves in vacuum, v is its speed in medium, ϵ_r and μ_r are the relative permittivity and permeability of the medium respectively. In normal materials, both ϵ_r and μ_r are positive, implying positive n for the medium. When both ϵ_r and μ_r are negative, one must choose the negative root of n. Such negative refractive index materials can now be artificially prepared and are called meta-materials. They exhibit significantly different optical behavior, without violating any physical laws. Since n is negative, it results in a change in direction of propagation of the refracted light. However, similar to normal materials, the frequency of light remains unchanged upon refraction even in meta-materials.

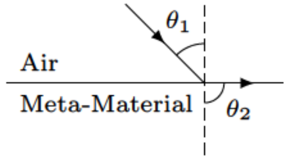
(2012)

Q 19. For light incident from air on a meta-material, the appropriate ray diagram is

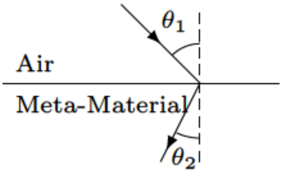
(A)



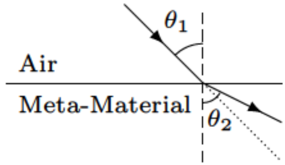
(B)



(C)



(D)



Q 20. Choose the correct statement,

(A) The speed of light in meta material is $v = c|n|$.

(B) The speed of light in meta material is $v = \frac{c}{|n|}$.

(C) The speed of light in meta material is $v = c$.

(D) The wavelength of the light in meta-material (λ_m) is given by $\lambda_m = \lambda_{\text{air}}|n|$, where λ_{air} is the wavelength of the light in air.

Answers

1. D
2. A
3. C
4. D
5. C
6. B
7. A
8. B
9. A, B
10. B, D
11. D
12. A, B, C
13. A, C
14. A, C
15. A
16. D
17. C
18. D
19. C
20. B

IIT JEE 2011

IIT JEE 2011 was a single stage examination of two papers, Paper 1 and Paper 2, each of three hours duration. Each of the papers has three separate sections of physics, chemistry and mathematics. All questions were of objective type, designed to test comprehension, reasoning and analytical ability of the candidate.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper 1

The physics part of the paper contains 23 questions of maximum marks 80. The questions are divided into four sections (1) single correct answer type (2) multiple correct answers type (3) paragraph type and (4) integer type.

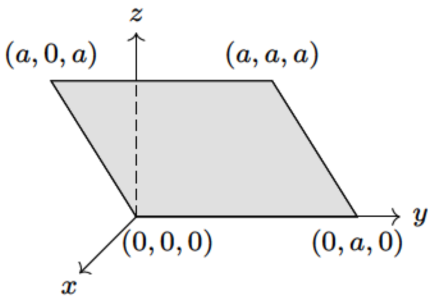
One Option Correct

This section contains 7 questions. Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: −1 In all other cases

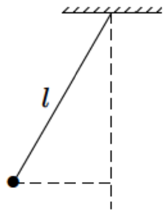
Q 1. 5.6 litre of helium gas at STP is adiabatically compressed to 0.7 litre. Taking the initial temperature to be T_1, the work done in the process is
(A) $\frac{9}{8}RT_1$ (B) $\frac{3}{2}RT_1$ (C) $\frac{15}{8}RT_1$ (D) $\frac{9}{2}RT_1$

Q 2. Consider an electric field $\vec{E} = E_0\,\hat{\imath}$, where E_0 is a constant. The flux through the shaded region (as shown in the figure) due to this field is



(A) $2E_0a^2$ (B) $\sqrt{2}E_0a^2$ (C) E_0a^2 (D) $\frac{E_0a^2}{2}$

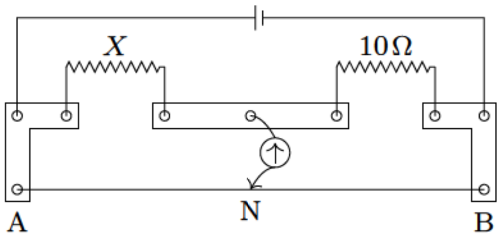
Q 3. A ball of mass (m) 0.5 kg is attached to the end of a string having length (l) 0.5 m. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is 324 N. The maximum possible value of angular velocity of the ball (in rad/s) is



(A) 9 (B) 18 (C) 27 (D) 36

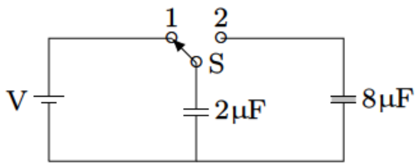
Q 4. The wavelength of the first spectral line in the Balmer series of hydrogen atom is 6561 Å. The wavelength of the second spectral line in the Balmer series of singly-ionized helium atom is
(A) 1215 Å (B) 1640 Å (C) 2430 Å (D) 4687 Å

Q 5. A metre bridge is set-up as shown, to determine an unknown resistance X using a standard $10\ \Omega$ resistor. The galvanometer shows null point when tapping-key is at 52 cm mark. The end corrections are 1 cm and 2 cm respectively for the ends A and B. The determined value of X is



(A) $10.2\ \Omega$ (B) $10.6\ \Omega$ (C) $10.8\ \Omega$ (D) $11.1\ \Omega$

Q 6. A 2 μF capacitor is charged as shown in the figure. The percentage of its stored energy dissipated after the switch S is turned to position 2 is



(A) 0 % (B) 20 % (C) 75 % (D) 80 %

Q 7. A police car with a siren of frequency 8 kHz is moving with uniform velocity 36 km/h towards a tall building which reflect the sound waves. The speed of sound in air is 320 m/s. The frequency of the siren heard by the car driver is

(A) 8.50 kHz (B) 8.25 kHz

(C) 7.75 kHz (D) 7.50 kHz

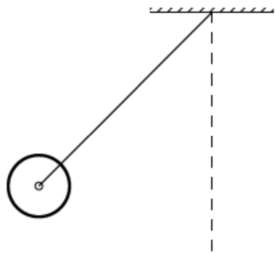
One or More Option(s) Correct

This section contains 4 questions. Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened

2. Zero Marks: (0) If none of the bubbles is darkened

Q 8. A metal rod of length L and mass m is pivoted at one end. A thin disc of mass M and radius R ($< L$) is attached at its centre to the free end of rod. Consider the two ways the disc is attached. (*Case A*) The disc is not free to rotate about its centre, and (*Case B*) the disc is free to rotate about its centre. The rod-disc system performs SHM in vertical plane after being released from the same displaced position. Which of the following statement(s) is (are) true?



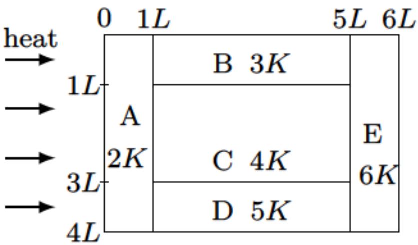
(A) restoring torque in case A = restoring torque in case B.

(B) restoring torque in case A < restoring torque in case B.

(C) Angular frequency of case A > Angular frequency of case B.

(D) Angular frequency of case A < Angular frequency of case B.

Q 9. A composite block is made of slabs A, B, C, D and E of different thermal conductivities (given in terms of constant K) and sizes (given in terms of length, L) as shown in the figure. All slabs are of same width. Heat Q flows only from left to right through the blocks. Then in steady state,



(A) heat flow through A and E slabs are same.
(B) heat flow through slab E is minimum.
(C) temperature difference across slab E is minimum.
(D) heat flow through C = heat flow through B + heat flow through D.

Q 10. An electron and a proton are moving on straight parallel paths with same velocity. They enter into semi-infinite region of uniform magnetic field perpendicular to their velocity. Which of the following statement(s) is (are) true?

(A) They will never come out of magnetic field region.
(B) They will come out traveling along parallel paths.
(C) They will come out at the same time.
(D) They will come out at different times.

Q 11. A spherical metal shell A of radius R_A and a solid metal sphere of radius R_B ($< R_A$) are kept far apart and each is given a charge $+Q$. Now they are connected by a thin metal wire. Then,

(A) $E_A^{\text{inside}} = 0$ (B) $Q_A > Q_B$

(C) $\frac{\sigma_A}{\sigma_B} = \frac{R_B}{R_A}$ (D) $E_A^{\text{on surface}} < E_B^{\text{on surface}}$

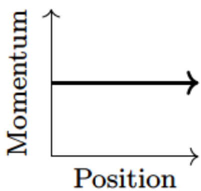
Paragraph Type

This section contains two paragraphs. Based on one of the paragraphs 3 multiple choice questions and based on other paragraph 2 multiple choice questions have to be answered. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

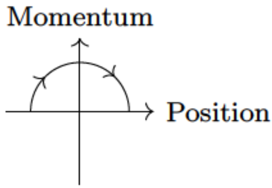
1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

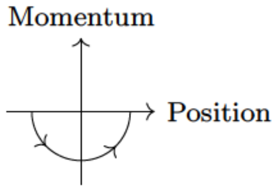
Paragraph for Questions 12-14

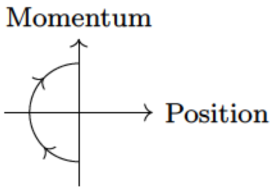
Phase space diagrams are useful tools in analysing all kinds of dynamical problems. They are especially useful in studying the changes in motion as initial position and momentum are changed. Here we consider some simple dynamical systems in one dimension. For such systems, phase space is a plane in which position is plotted along horizontal axis and momentum is plotted along vertical axis. The phase space diagram is $x(t)$ *versus* $p(t)$ curve in this plane. The arrow on curve indicates time flow. For example, the phase space diagram for a particle moving with constant velocity is a straight line as shown in the figure. We use the sign convention in which position or momentum upward (or to right) is positive and downwards (or towards left) is negative. (2011)

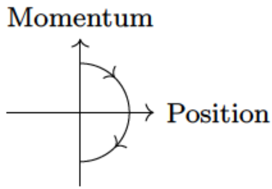


Q 12. The phase space diagram for a ball thrown vertically up from ground is

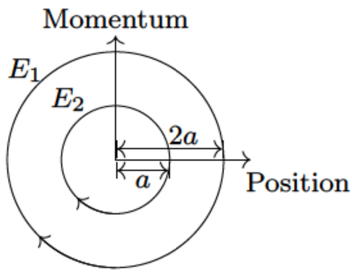
(A)


(B)


(C)


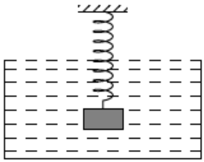
(D)


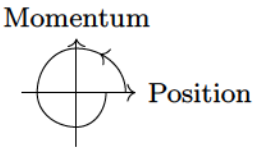
Q 13. The phase space diagram for SHM is a circle centered at the origin. In the figure, two circles represent the same oscillator but for different initial conditions, and E_1 and E_2 are total mechanical energies, respectively. Then,

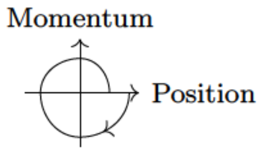


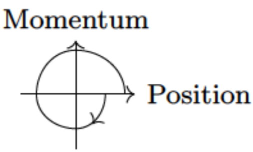
(A) $E_1 = \sqrt{2}E_2$ (B) $E_1 = 2E_2$
(C) $E_1 = 4E_2$ (D) $E_1 = 16E_2$

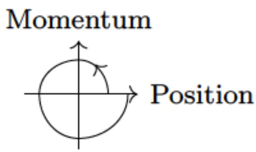
Q 14. Consider the spring mass system, with mass submerged in water, as shown in the figure. The phase space diagram for one cycle of this system is



(A) 

(B) 

(C) 

(D) 

Paragraph for Questions 15-16

A dense collection of equal number of electrons and positive ions is called neutral plasma. Certain solids containing fixed positive ions surrounded by free electrons can be treated as neutral plasma. Let N be number density of free electrons, each of mass m. When the electrons are subjected to an electric field, they are displaced relatively away from the heavy positive ions. If the electric field become zero, the electrons begin to oscillate about positive ions with natural frequency ω_p, which is called plasma frequency. To sustain the oscillations, a time varying electric field needs to be applied that has an angular frequency ω, where a part of energy is absorbed and a part of it is reflected. As ω approaches ω_p, all the free electrons are set to resonate together and all the energy is reflected. This is the explanation for high reflectivity of metals. (2011)

Q 15. Taking the electronic charge as e and permittivity as ϵ_0, use dimensional analysis to determine correct expression for ω_p.

(A) $\sqrt{\frac{Ne}{m\epsilon_0}}$ (B) $\sqrt{\frac{m\epsilon_0}{Ne}}$ (C) $\sqrt{\frac{Ne^2}{m\epsilon_0}}$ (D) $\sqrt{\frac{m\epsilon_0}{Ne^2}}$

Q 16. Estimate the wavelength at which plasma reflection will occur for a metal having the density of electron $N = 4 \times 10^{27}\ \mathrm{m}^{-3}$. Take $\epsilon_0 = 10^{-11}$ and $m = 10^{-30}$, where these quantities are in proper SI units.

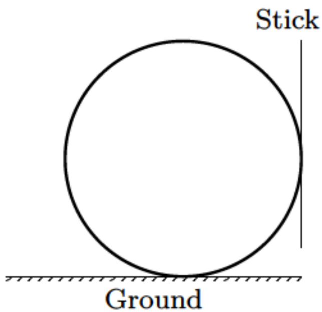
(A) 800 nm (B) 600 nm (C) 300 nm (D) 200 nm

Integer Type

This section contains 7 questions. The answer to each question in this section is a single digit integer ranging from 0 to 9, both inclusive. Marking scheme:

1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

Q 17. A boy is pushing a ring of mass 2 kg and radius 0.5 m with a stick as shown in the figure. The stick applies a force of 2 N on the ring and rolls without slipping with an acceleration of 0.3 m/s^2. The coefficient of friction between the ground and the ring is large enough that rolling always occurs and the coefficient of friction between the stick and ring is $P/10$. The value of P is ....



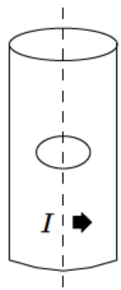
Q 18. A block is moving on an inclined plane making an angle 45° with the horizontal and the coefficient of friction is μ. The force required to just push it up the inclined plane is three times the force required to just prevent it from sliding down. If we define $N = 10\mu$ then N is . . . .

Q 19. Four point charges, each of $+q$, are rigidly fixed at the four corners of a square planar soap film of side a. The surface tension of soap film is γ. The system of charges and planar film are in equilibrium and $a = k\left[q^2/\gamma\right]^{1/N}$ where k is a constant. Then N is ....

Q 20. Steel wire of length L at 40 °C is suspended from ceiling and then a mass m is hung from its free end. The wire is cooled down from 40 °C to 30 °C to regain its original length L. The coefficient of linear thermal expansion of the steel is 10^{-5} /°C, Young's modulus for steel is 10^{11} N/m^2 and radius of the wire is 1 mm. Assume $L \gg$ diameter of the wire. Then the value of m (in kg) is nearly ....

Q 21. The activity of a freshly prepared radioactive sample is 10^{10} dis-integration per second, whose mean life is 10^9 s. The mass of an atom of this radioisotope is 10^{-25} kg. The mass (in mg) of the radioactive sample is ....

Q 22. A long circular tube of length 10 m and radius 0.3 m carries a current I along its curved surface as shown. A wire-loop of resistance $0.005\,\Omega$ and of radius 0.1 m is placed inside the tube with its axis coinciding with the axis of tube. The current varies as $I = I_0 \cos(300t)$, where I_0 is constant. If magnetic moment of the loop is $N\mu_0 I_0 \sin(300t)$, then N is ....



Q 23. Four solid spheres each of diameter $\sqrt{5}$ cm and mass 0.5 kg are placed with their centers at the corner of a square of side 4 cm. The moment of inertia of the system about the diagonal of the square is $\mathrm{N} \times 10^{-4}$ kg m^2, then N is ....

Answers

1. A
2. C
3. D
4. A
5. B
6. D
7. A
8. A, D
9. A, C, D
10. B, D
11. A, B, C, D
12. D
13. C
14. B
15. C
16. B
17. 4
18. 5
19. 3
20. 3
21. 1
22. 6
23. 9

Paper 2

The physics part of the paper contains 20 questions of maximum marks 80. The questions are divided into four sections (1) single correct answer type (2) multiple correct answers type (3) integer type and (4) matrix-matching type.

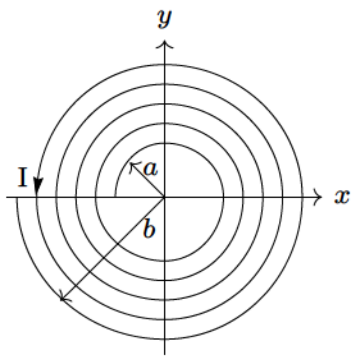
One Option Correct

This section contains 8 questions. Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 1. A satellite is moving with a constant speed V in a circular orbit about earth. An object of mass m is ejected from the satellite such that it just escapes from the gravitational pull of the earth. At the time of its injection, the kinetic energy of the object is
(A) $\frac{1}{2}mV^2$ (B) mV^2 (C) $\frac{3}{2}mV^2$ (D) $2mV^2$

Q 2. A long insulated copper wire is closely wound as a spiral of N turns. The spiral has inner radius a and outer radius b. The spiral lies in x-y plane and a steady current I flows through the wire. The z component of magnetic field at the centre of spiral is



(A) $\frac{\mu_0 NI}{2(b-a)} \ln\left(\frac{b}{a}\right)$ (B) $\frac{\mu_0 NI}{2(b-a)} \ln\left(\frac{b+a}{b-a}\right)$

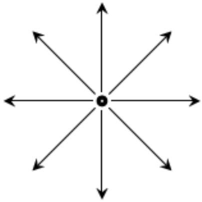
(C) $\frac{\mu_0 NI}{2b} \ln\left(\frac{b}{a}\right)$ (D) $\frac{\mu_0 NI}{2b} \ln\left(\frac{b+a}{b-a}\right)$

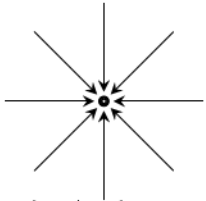
Q 3. A point mass is subjected to two simultaneous sinusoidal displacements in x direction, $x_1(t) = A\sin(\omega t)$ and $x_2(t) = A\sin\left(\omega t + \frac{2\pi}{3}\right)$. Adding a third sinusoidal displacement $x_3(t) = B\sin(\omega t + \phi)$ brings the mass to complete rest. The value of B and ϕ are

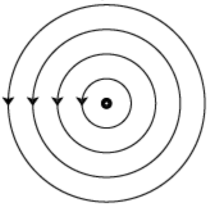
(A) $\sqrt{2}A$, $3\pi/4$ (B) A, $4\pi/3$

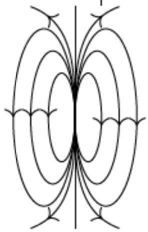
(C) $\sqrt{3}A$, $5\pi/6$ (D) A, $\pi/3$

Q 4. Which of the field pattern given below is valid for electric field as well as for magnetic field?

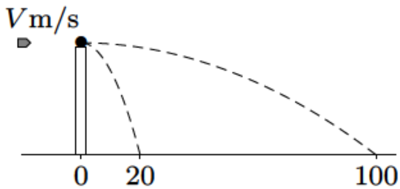
(A) 

(B) 

(C) 

(D) 

Q 5. A ball of mass 0.2 kg rests on vertical post of height 5 m. A bullet of mass 0.01 kg, travelling with velocity V m/s in horizontal direction, hits the centre of the ball. After the collision, the ball and the bullet travel independently. The ball hits the ground at a distance of 20 m and the bullet at a distance of 100 m from the foot of the post. The initial velocity V of the bullet is [Take $g = 10$ m/s^2.]



(A) 250 m/s (B) $250\sqrt{2}$ m/s
(C) 400 m/s (D) 500 m/s

Q 6. The density of a solid ball is to be determined in an experiment. The diameter of the ball is measured with a screw gauge, whose pitch is 0.5 mm and there are 50 divisions on the circular scale. The reading on the main scale is 2.5 mm and that on the circular scale is 20 divisions. If the measured mass of the ball has relative error of 2%, the percentage error in density is

(A) 0.9 % (B) 2.4 % (C) 3.1 % (D) 4.2 %

Q 7. A wooden block performs SHM on a frictionless surface with frequency ν_0. The block contains a charge $+q$ on its surface. If now, a uniform electric field $\vec{E}$ is switched on as shown, then SHM of the block will be

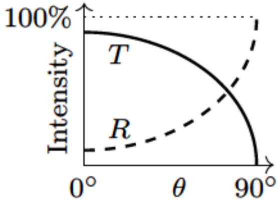
(A) of the same frequency and with shifted mean position.

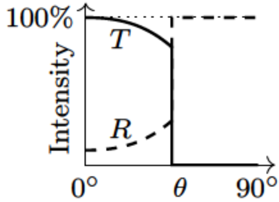
(B) of the same frequency and with same mean position.

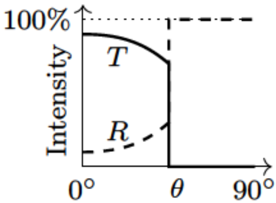
(C) of changed frequency and with shifted mean position.

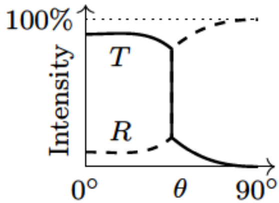
(D) of changed frequency with same mean position.

Q 8. A light ray travelling in glass medium is incident on glass-air interface at an angle of incidence θ. The reflected (R) and transmitted (T) intensities, both as a function of θ are plotted. The correct sketch is

(A) 

(B) 

(C) 

(D) 

One or More Option(s) Correct

This section contains 4 questions. Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) In all other cases

Q 9. Which of the following statement(s) is (are) correct?

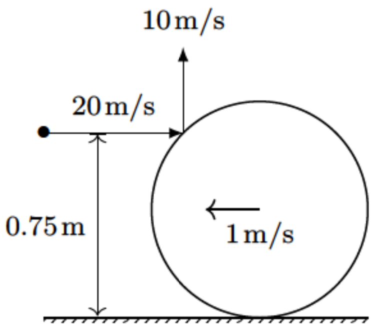
(A) If electric field due to a point charge varies as $r^{-2.5}$ instead of r^{-2}, then the Gauss law will still be valid.

(B) The Gauss law can be used to calculate the field distribution around an electric dipole.

(C) If the electric field between two point charges is zero somewhere, then the sign of two charges is the same.

(D) The work done by the external force in moving a unit positive charge from point A at potential V_A to point B at potential V_B is $V_B - V_A$.

Q 10. A thin ring of mass 2 kg and radius 0.5 m is rolling without slipping on a horizontal plane with velocity 1 m/s. A small ball of mass 0.1 kg, moving with velocity 20 m/s in the opposite direction, hits the ring at a height of 0.75 m and goes vertically up with velocity 10 m/s. Immediately after the collision,



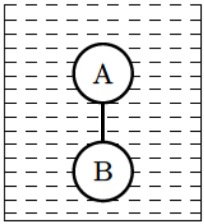
(A) the ring has pure rotation about stationary CM.
(B) the ring comes to a complete stop.
(C) friction between the ring and the ground is to the left.
(D) there is no friction between the ring and the ground.

Q 11. A series R-C circuit is connected to AC voltage source. Consider two cases (A) when C is without a dielectric medium and (B) when C is filled with dielectric medium of dielectric constant 4. The current I_R through the resistor and voltage V_C across the capacitor are compared in two cases. Which of the following is (are) true?

(A) $I_R^A > I_R^B$ (B) $I_R^A < I_R^B$

(C) $V_C^A > V_C^B$ (D) $V_C^A < V_C^B$

Q 12. Two solid spheres A and B of equal volumes but of different densities d_A and d_B are connected by a string. They are fully immersed in a fluid of density d_F. They get arranged into equilibrium state as shown in the figure with a tension in the string. The arrangement is possible only if



(A) $d_A < d_F$ (B) $d_B > d_F$
(C) $d_A > d_F$ (D) $d_A + d_B = 2d_F$

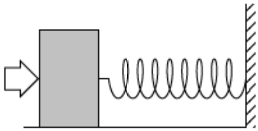
Integer Type

This section contains 6 questions. The answer to each question in this section is a single digit integer ranging from 0 to 9, both inclusive. Marking scheme is:

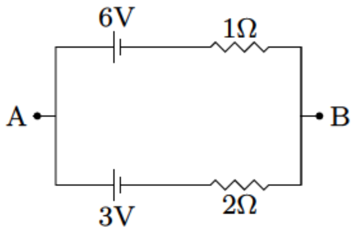
1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

Q 13. A train is moving along straight line with a constant acceleration a. A boy standing in the train throws a ball forward with a speed of 10 m/s at an angle 60° from horizontal. The boy has to move forward by 1.15 m inside the train to catch the ball back at the initial height. The acceleration of the train in m/s^2 is ....

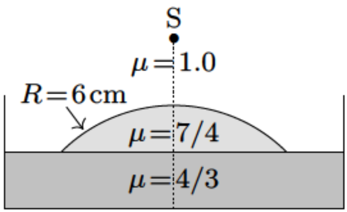
Q 14. A block of mass 0.18 kg is attached to a spring of force constant 2 N/m. The coefficient of friction between the block and floor is 0.1. Initially, the block is at rest and the spring is un-stretched. An impulse is given to the block as shown in the figure. The block slides a distance of 0.06 m and comes to rest for the first time. The initial velocity of the block (in m/s) is $V = N/10$. Then N is . . . .



Q 15. Two batteries of different *emfs* and different internal resistances are connected as shown. The voltage across AB (in volts) is ....



Q 16. Water (with refractive index 4/3) in a tank is 18 cm deep. Oil of refractive index 7/4 lies on water making a convex surface of radius of curvature $R = 6$ cm as shown in the figure. Consider oil to act as thin lens. An object S is placed 24 cm above water surface. The location of its image is at x cm above the bottom of tank. Then x is ....



Q 17. A series R-C combination is connected to an AC voltage of angular frequency $\omega = 500\,\text{rad/s}$. If the impedance of the R-C circuit is $R\sqrt{1.25}$, the time constant (in milliseconds) of the circuit is $\ldots\ldots\ldots$

Q 18. A silver sphere of radius 1 cm and work function 4.7 eV is suspended from an insulating thread in free-space. It is under continuous illumination of 200 nm wavelength light. As photoelectrons are emitted, the sphere gets charged and acquires a potential. The maximum number of photoelectrons emitted from the sphere is $A \times 10^Z$ (where $1 < A < 10$). The value of Z is ....

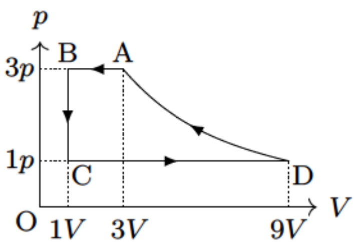
Matrix or Matching Type

This section contains 2 questions of total marks 16. Each question contains two columns, column I and column II. Column I has four entries (A), (B), (C) and (D). Column II has five entries (p), (q), (r), (s) and (t). Match the entries in column I with entries in column II. Any given statement in column I can have correct matching with one or more statement(s) given in column II. For each entry in column I, darken the bubbles of all the matching entries. For example, if entry (A) in column I matches with entries (q), (r) and (t), then darken these three bubbles. Similarly, for entries (B), (C) and (D). Marking scheme for each entry in column I is:

1. Full Marks: (+2) If only the bubble corresponding to the correct answer is darkened

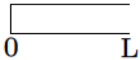
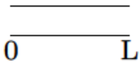
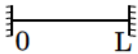
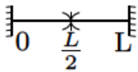
2. Zero Marks: (0) In all other cases

Q 19. One mole of monatomic gas is taken through a cycle ABCDA as shown in the p-V diagram. *Column II* gives the characteristics involved in the cycle. Match them with each of the processes given in *Column I*.



Column I	Column II
(A) $A \to B$	(p) Internal energy decreases.
(B) $B \to C$	(q) Internal energy increases.
(C) $C \to D$	(r) Heat is lost.
(D) $D \to A$	(s) Heat is gained.
	(t) Work is done on the gas.

Q 20. *Column I* shows four systems, each of the same length L for producing standing waves. The lowest possible natural frequency of the system is called its fundamental frequency, whose wavelength is denoted by λ_f. Match each system with statement given in *column II* describing the nature and wavelength of standing waves,

Column I	Column II
(A) Pipe close at one end. 	(p) Longitudinal waves
(B) Pipe open at both ends. 	(q) Transverse waves
(C) Stretched wire clamped at both ends. 	(r) $\lambda_f = L$
(D) Stretched wire clamped at both ends and at mid point. 	(s) $\lambda_f = 2L$
	(t) $\lambda_f = 4L$

Answers

1. B
2. A
3. B
4. C
5. D
6. C
7. A
8. C
9. C, D
10. A, C
11. B, C
12. A, B, D
13. 5
14. 4
15. 5
16. 2
17. 4
18. 7
19. A$\mapsto$(p,r,t), B$\mapsto$(p,r), C$\mapsto$(q,s), D$\mapsto$(r,t)
20. A$\mapsto$(p,t), B$\mapsto$(p,s), C$\mapsto$(q,s), D$\mapsto$(q,r)

IIT JEE 2010

IIT JEE 2010 was a single stage examination of two papers, Paper 1 and Paper 2, each of three hours duration. Each of the papers has three separate sections of physics, chemistry and mathematics. All questions were of objective type, designed to test comprehension, reasoning and analytical ability of the candidate.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper 1

The physics part of the paper contains 28 questions. The questions are divided into four sections (1) single correct answer type (2) multiple correct answers type (3) paragraph type and (4) integer type.

One Option Correct

This section contains 8 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

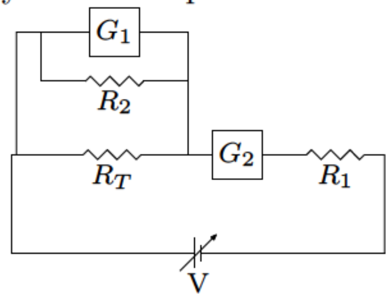
Q 1. A real gas behaves like an ideal gas if its
(A) pressure and temperature are both high.
(B) pressure and temperature are both low.
(C) pressure is high and temperature is low.
(D) pressure is low and temperature is high.

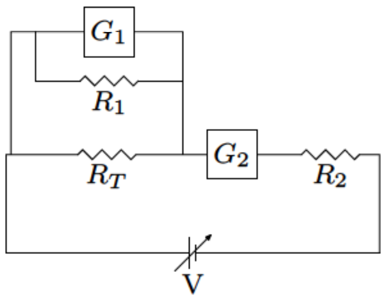
Q 2. Incandescent bulbs are designed by keeping in mind that the resistance of their filament increases with increase in temperature. If at room temperature, 100 W, 60 W and 40 W bulbs have filament resistances R_{100}, R_{60} and R_{40}, respectively, the relation between these resistances is

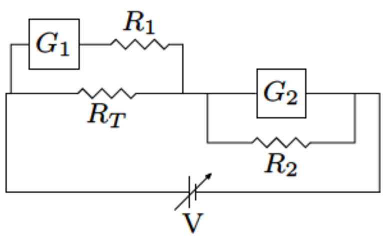
(A) $\frac{1}{R_{100}} = \frac{1}{R_{40}} + \frac{1}{R_{60}}$ (B) $R_{100} = R_{40} + R_{60}$

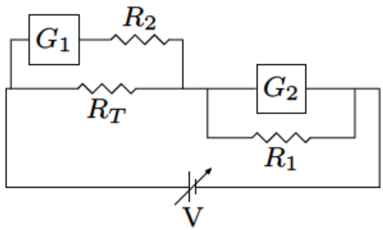
(C) $R_{100} > R_{60} > R_{40}$ (D) $\frac{1}{R_{100}} > \frac{1}{R_{60}} > \frac{1}{R_{40}}$

Q 3. To verify Ohm's law, a student is provided with a test resister R_T, a high resistance R_1, and a small resistance R_2, two identical galvanometers G_1 and G_2, and a variable voltage source V. The correct circuit to carry out the experiment is

(A) 

(B) 

(C) 

(D) 

Q 4. An AC voltage source of variable angular frequency ω and fixed amplitude V_0 is connected in series with a capacitance C and an electric bulb of resistance R (inductance zero). When ω is increased,

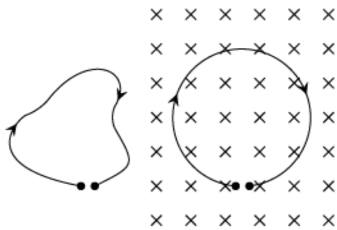
(A) the bulb glows dimmer.

(B) the bulb glows brighter.

(C) total impedance of the circuit is unchanged.

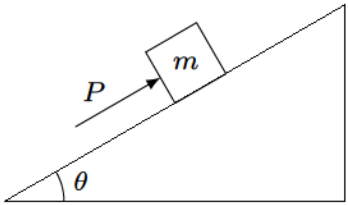
(D) total impedance of the circuit increases.

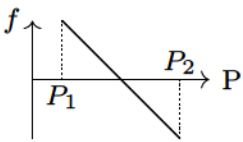
Q 5. A thin flexible wire of length L is connected to two adjacent fixed points and carries current I in the clockwise direction as shown in the figure. When the system is put in a uniform magnetic field of strength B going into the plane of the paper, the wire takes the shape of a circle. The tension in the wire is

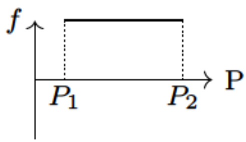


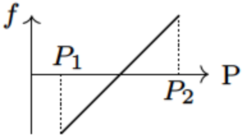
(A) IBL (B) $\frac{IBL}{\pi}$ (C) $\frac{IBL}{2\pi}$ (D) $\frac{IBL}{4\pi}$

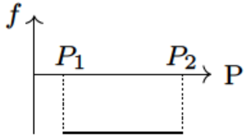
Q 6. A block of mass m is on an inclined plane of angle θ. The coefficient of friction between the block and the plane is μ and $\tan\theta > \mu$. The block is held stationary by applying a force P parallel to the plane. The direction of force pointing up the plane is taken to be positive. As P is varied from $P_1 = mg(\sin\theta - \mu\cos\theta)$ to $P_2 = mg(\sin\theta + \mu\cos\theta)$, the frictional force f *versus* P graph will look like



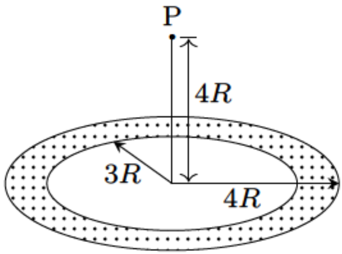
(A) 

(B) 

(C) 

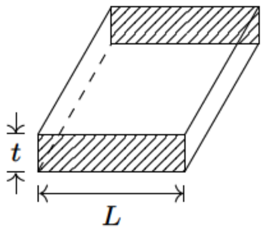
(D) 

Q 7. A thin uniform annular disc (see figure) of mass M has outer radius $4R$ and inner radius $3R$. The work required to take a unit mass from point P on its axis to infinity is



(A) $\frac{2GM}{7R}\left(4\sqrt{2}-5\right)$ (B) $-\frac{2GM}{7R}\left(4\sqrt{2}-5\right)$
(C) $\frac{GM}{4R}$ (D) $\frac{2GM}{5R}\left(\sqrt{2}-1\right)$

Q 8. Consider a thin square sheet of side L and thickness t, made of material of resistivity ρ. The resistance between two opposite faces, shown by the shaded areas in the figure is



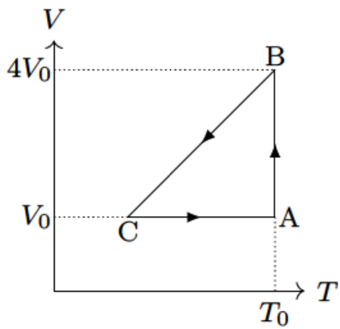
(A) directly proportional to L.
(B) directly proportional to t.
(C) independent of L.
(D) independent of t.

One or More Option(s) Correct

This section contains 5 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

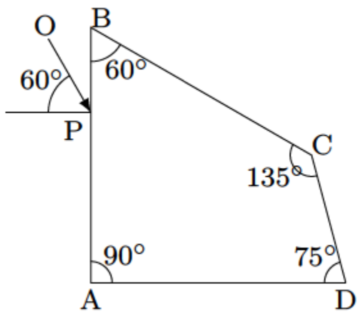
1. Full Marks: (+3) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Partial Marks: (+1) For darkening a bubble corresponding to each correct option, provided NO incorrect option is darkened
3. Zero Marks: (0) If none of the bubbles is darkened

Q 9. One mole of an ideal gas in initial state A undergoes a cyclic process ABCA as shown in the figure. Its pressure at A is p_0. Choose the correct option(s) from the following,



(A) Internal energies at A and B are the same.
(B) Work done by the gas in process AB is $p_0 V_0 \ln 4$.
(C) Pressure at C is $p_0/4$.
(D) Temperature at C is $T_0/4$.

Q 10. A ray OP of monochromatic light is incident on the face AB of prism ABCD near vertex B at an incident angle of 60° (see figure). If the refractive index of the material of the prism is $\sqrt{3}$, which of the following is (are) correct?



(A) The ray gets totally internally reflected at face CD.
(B) The ray comes out through face AD.
(C) The angle between the incident ray and the emergent ray is 90°.
(D) The angle between the incident ray and the emergent ray is 120°.

Q 11. A student uses a simple pendulum of exactly 1 m length to determine g, the acceleration due to gravity. He uses a stop watch with the least count of 1 s for this and records 40 s for 20 oscillations. For this observation, which of the following statement(s) is (are) true?

(A) Error ΔT in measuring time period T is 0.05 s.
(B) Error ΔT in measuring time period T is 1 s.
(C) Percentage error in the determination of g is 5%.
(D) Percentage error in the determination of g is 2.5%.

Q 12. A point mass of 1 kg collides elastically with a stationary mass of 5 kg. After their collision, the 1 kg mass reverses its direction and moves with speed of 2 m/s. Which of the following statement(s) is (are) correct for the system of these two masses?

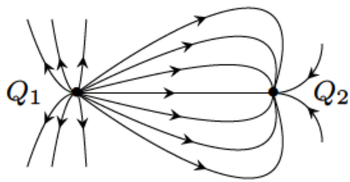
(A) Total momentum of the system is 3 kg m/s.

(B) Momentum of 5 kg mass after collision is 4 kg m/s.

(C) Kinetic energy of the centre of mass is 0.75 J.

(D) Total kinetic energy of the system is 4 J.

Q 13. A few electric field lines for a system of two charges Q_1 and Q_2 fixed at two different points on the x-axis are shown in the figure. These lines suggest that



(A) $|Q_1| > |Q_2|$.
(B) $|Q_1| < |Q_2|$.
(C) at a finite distance to the left of Q_1 the electric field is zero.
(D) at a finite distance to the right of Q_2 the electric field is zero.

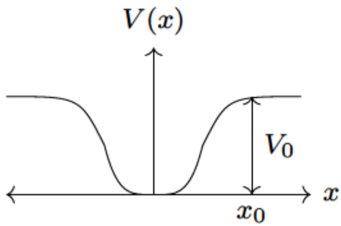
Paragraph Type

This section contains two paragraphs. Based on one of the paragraphs 3 multiple choice questions and based on other paragraph 2 multiple choice questions have to be answered. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 14-16

When a particle of mass m moves on the x-axis in a potential of the form $V(x) = kx^2$, it performs SHM. The corresponding time period is proportional to $\sqrt{m/k}$, as can be seen easily using dimensional analysis. However, the motion of a particle can be periodic even when its potential energy increases on both sides of $x = 0$ in a way different from kx^2 and its total energy is such that the particle does not escape to infinity. Consider a particle of mass m moving on the x-axis. Its potential energy is $V(x) = \alpha x^4$ $(\alpha > 0)$ for $|x|$ near the origin and becomes a constant equal to V_0 for $|x| \geq x_0$ (see figure). (2010)



Q 14. If the total energy of the particle is E, it will have periodic motion only if
(A) $E < 0$ (B) $E > 0$ (C) $V_0 > E > 0$ (D) $E > V_0$

Q 15. For periodic motion of small amplitude A, the time period T of this particle is proportional to
(A) $A\sqrt{\frac{m}{\alpha}}$ (B) $\frac{1}{A}\sqrt{\frac{m}{\alpha}}$ (C) $A\sqrt{\frac{\alpha}{m}}$ (D) $\frac{1}{A}\sqrt{\frac{\alpha}{m}}$

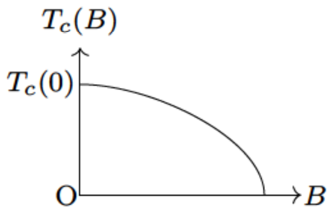
Q 16. The acceleration of this particle for $|x| > |x_0|$ is

(A) proportional to $\frac{V_0}{mx_0}$ (B) proportional to V_0

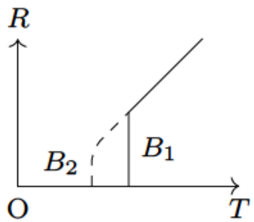
(C) proportional to $\sqrt{\frac{V_0}{mx_0}}$ (D) zero

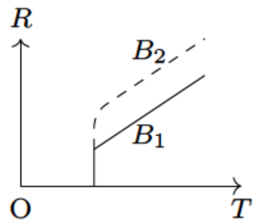
Paragraph for Questions 17-18

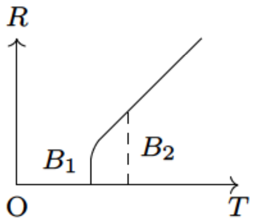
Electrical resistance of certain materials, known as superconductors, changes abruptly from a nonzero value to zero as their temperature is lowered below a critical temperature $T_c(0)$. An interesting property of superconductors is that their critical temperature become smaller than $T_c(0)$ if they are placed in a magnetic field i.e., the critical temperature $T_c(B)$ is a function of the magnetic field strength B. The dependence of $T_c(B)$ on B is shown in the figure. **(2010)**

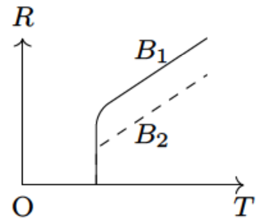


Q 17. In the graph below, the resistance R of a superconductor is shown as a function of its temperature T for two different magnetic fields B_1 (solid line) and B_2 (dashed line). If B_2 is larger than B_1, which of the following graphs shows the correct variation of R with T in these fields?

(A)


(B)


(C)


(D)


Q 18. A superconductor has $T_c(0) = 100\,\text{K}$. When a magnetic field of 7.5 Tesla is applied, its T_c decreases to $75\,\text{K}$. For this material one can definitely say that when,

(A) $B = 5$ Tesla, $T_c(B) = 80$ K
(B) $B = 5$ Tesla, $75\text{ K} < T_c(B) < 100\text{ K}$
(C) $B = 10$ Tesla, $75\text{ K} < T_c(B) < 100\text{ K}$
(D) $B = 10$ Tesla, $T_c(B) = 70$ K

Integer Type

This section contains 10 questions. The answer to each question in this section is a single digit integer ranging from 0 to 9, both inclusive. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

Q 19. The focal length of a thin biconvex lens is 20 cm. When an object is moved from a distance of 25 cm in front of it to 50 cm, the magnification of its image changes from m_{25} to m_{50}. The ratio $\frac{m_{25}}{m_{50}}$ is ....

Q 20. An α-particle and a proton are accelerated from rest by a potential of 100 V. After this, their de-Broglie wavelengths are λ_α and λ_p respectively. The ratio λ_p/λ_α, to the nearest integer, is ....

Q 21. When two identical batteries of internal resistance $1\,\Omega$ each are connected in series across a resistor R, the rate of heat produced in R is J_1. When the same batteries are connected in parallel across R, the rate is J_2. If $J_1 = 2.25 J_2$ then the value of R (in Ω) is $\ldots\ldots.$

Q 22. Two spherical bodies A (radius 6 cm) and B (radius 18 cm) are at temperatures T_1 and T_2, respectively. The maximum intensity in the emission spectrum of A is at 500 nm and in that of B is at 1500 nm. Considering them to be black bodies, what will be the ratio of the rate of total energy radiated by A to that of B?

Q 23. When two progressive waves $y_1 = 4\sin(2x - 6t)$ and $y_2 = 3\sin(2x - 6t - \frac{\pi}{2})$ are superimposed, the amplitude of the resultant wave is ....

Q 24. A 0.1 kg mass is suspended from a wire of negligible mass. The length of the wire is 1 m and its cross-sectional area is 4.9×10^{-7} m^2. If the mass is pulled a little in the vertically downward direction and released, it performs SHM of angular frequency 140 rad/s. If the Young's modulus of the material of the wire is $n \times 10^9$ N/m^2, the value of n is . . . .

Q 25. A binary star consists of two stars A (mass $2.2M_s$) and B (mass $11M_s$), where M_s is the mass of the sun. They are separated by distance r and are rotating about their centre of mass, which is stationary. The ratio of the total angular momentum of the binary star to the angular momentum of star B about the centre of mass is ....

Q 26. Gravitational acceleration on the surface of a planet is $\frac{\sqrt{6}}{11}g$, where g is the gravitational acceleration on the surface of the earth. The average mass density of the planet is 2/3 times that of the earth. If the escape speed on the surface of the earth is taken to be 11 km/s, the escape velocity on the surface of the planet (in km/s) will be ....

Q 27. A piece of ice of mass m grams is at $-5\ ^{\circ}\mathrm{C}$ at atmospheric pressure. It is given 420 J of heat so that the ice starts melting. Finally when the ice-water mixture is in equilibrium, it is found that 1 g of ice has melted. Assuming there is no other heat exchange in the process, the value of m is .... [Given: ice heat capacity $= 2100\ \mathrm{J/(kg^{\circ}C)}$ and latent heat $= 3.36 \times 10^5\ \mathrm{J/kg}$.]

Q 28. A stationary source is emitting sound at a fixed frequency f_0, which is reflected by two cars approaching the source. The difference between the frequencies of sound reflected from the cars is 1.2% of f_0. What is the difference in the speeds of the cars (in km/h) to the nearest integer? The cars are moving at constant speeds much smaller than the speed of sound which is 330 m/s.

Answers

1. D
2. D
3. C
4. B
5. C
6. A
7. A
8. C
9. A, B, C, D
10. A, B, C
11. A, C
12. A, C
13. A, D
14. C
15. B
16. D
17. A
18. B
19. 6
20. 3
21. 4
22. 9
23. 5
24. 4
25. 6
26. 3
27. 8
28. 7

Paper 2

The physics part of the paper contains 19 questions. The questions are divided into four sections (1) single correct answer type (2) integer type (3) paragraph type and (4) matrix-matching type.

One Option Correct

This section contains 6 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+5) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: −2 In all other cases

Q 1. A Vernier calipers has 1 mm marks on the main scale. It has 20 equal divisions on the Vernier scale which match with 16 main scale divisions. For this Vernier calipers, the least count is

(A) 0.02 mm (B) 0.05 mm (C) 0.1 mm (D) 0.2 mm

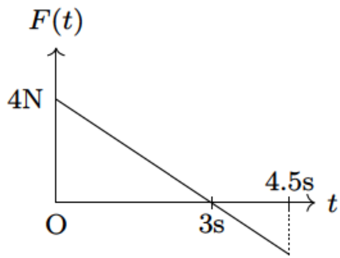
Q 2. A hollow pipe of length 0.8 m is closed at one end. At its open end a 0.5 m long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of the pipe. If the tension in the string is 50 N and the speed of sound is 320 m/s, the mass of the string is

(A) 5 grams (B) 10 grams
(C) 20 grams (D) 40 grams

Q 3. A biconvex lens of focal length 15 cm is in front of a plane mirror. The distance between the lens and the mirror is 10 cm. A small object is kept at a distance of 30 cm from the lens. The final image is

(A) virtual and at a distance of 16 cm from the mirror.
(B) real and at a distance of 16 cm from the mirror.
(C) virtual and at a distance of 20 cm from the mirror.
(D) real and at a distance of 20 cm from the mirror.

Q 4. A block of mass 2 kg is free to move along the x-axis. It is at rest and from $t = 0$ onwards it is subjected to a time dependent force $F(t)$ in the x direction. The force $F(t)$ varies with t as shown in the figure. The kinetic energy of the block after 4.5 seconds is



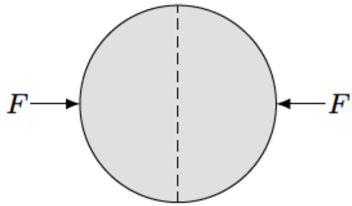
(A) 4.50 J (B) 7.50 J (C) 5.06 J (D) 14.06 J

Q 5. A tiny spherical oil drop carrying net charge q is balanced in still air with a vertical uniform electric field of strength $\frac{81\pi}{7} \times 10^5$ V/m. When the field is switched off, the drop is observed to fall with terminal velocity 2×10^{-3} m/s. Given $g = 9.8\,\text{m/s}^2$, viscosity of the air $= 1.8 \times 10^{-5}\,\text{N}\cdot\text{s/m}^2$ and the density of oil $=$ $900\,\text{kg/m}^3$, the magnitude of q is

(A) 1.6×10^{-19} C (B) 3.2×10^{-19} C

(C) 4.8×10^{-19} C (D) 8.0×10^{-19} C

Q 6. A uniformly charged thin spherical shell of radius R carries uniform surface charge density of σ per unit area. It is made of two hemispherical shells, held together by pressing them with force F (see figure). The force F is proportional to



(A) $\frac{1}{\epsilon_0}\sigma^2 R^2$ (B) $\frac{1}{\epsilon_0}\sigma^2 R$ (C) $\frac{1}{\epsilon_0}\frac{\sigma^2}{R}$ (D) $\frac{1}{\epsilon_0}\frac{\sigma^2}{R^2}$

Integer Type

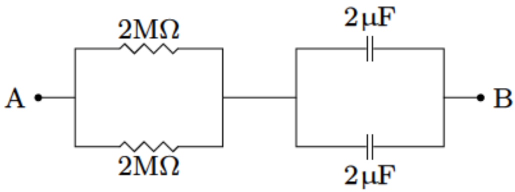
This section contains 5 questions. The answer to each question in this section is a single digit integer ranging from 0 to 9, both inclusive. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened

2. Zero Marks: (0) In all other cases

Q 7. A diatomic ideal gas is compressed adiabatically to 1/32 of its initial volume. If the initial temperature of the gas is T_i (in Kelvin) and the final temperature is aT_i, the value of a is ....

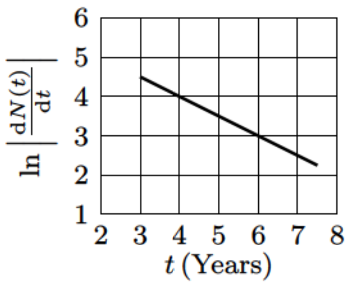
Q 8. At time $t = 0$, a battery of 10 V is connected across points A and B in the given circuit. If the capacitors have no charge initially, at what time (in seconds) does the voltage across them become 4 V? [Take $\ln 5 = 1.6, \ln 3 = 1.1$].



Q 9. Image of an object approaching a convex mirror of radius of curvature 20 m along its optical axis is observed to move from $\frac{25}{3}$ m to $\frac{50}{7}$ m in 30 seconds. What is the speed (in km/h) of the object?

Q 10. A large slab ($\mu = 5/3$) of thickness 8 cm is placed over a point source of light on a plane surface. It is seen that light emerges out of the top surface of the slab from a circular area of radius R cm. What is the value of R?

Q 11. To determine the half life of a radioactive element, a student plots a graph of $\ln\left|\frac{dN(t)}{dt}\right|$ *versus* t. Here $\frac{dN(t)}{dt}$ is the rate of radioactive decay at time t. If the number of radioactive nuclei of this element decreases by a factor of p after 4.16 years, the value of p is ....



Paragraph Type

This section contains 6 question based on two paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 12-14

When liquid medicine of density ρ is to be put in the eye, it is done with the help of a dropper. As the bulb on the top of the dropper is pressed, a drop forms at the opening of the dropper. We wish to estimate the size of the drop. We first assume that the drop formed at the opening is spherical because that requires a minimum increase in its surface energy. To determine the size, we calculate the net vertical force due to the surface tension T when the radius of the drop is R. When this force becomes smaller than the weight of the drop, the drop gets detached from the dropper. (2010)

Q 12. If the radius of the opening of the dropper is r, the vertical force due to the surface tension on the drop of radius R (assuming $r \ll R$) is

(A) $2\pi rT$ (B) $2\pi RT$ (C) $\frac{2\pi r^2 T}{R}$ (D) $\frac{2\pi R^2 T}{r}$

Q 13. If $r = 5 \times 10^{-4}$ m, $\rho = 10^3$ kg/m^3, $g = 10$ m/s^2, $T = 0.11$ N/m, the radius of the drop when it detaches from the dropper is approximately

(A) 1.4×10^{-3} m (B) 3.3×10^{-3} m

(C) 2.0×10^{-3} m (D) 4.1×10^{-3} m

Q 14. After the drop detaches, its surface energy is
(A) 1.4×10^{-6} J (B) 2.7×10^{-6} J
(C) 5.4×10^{-6} J (D) 8.1×10^{-6} J

Paragraph for Questions 15-17

The key features of Bohr's theory of spectrum of hydrogen atom is the quantization of angular momentum when an electron is revolving around a proton. We will extend this to a general rotational motion to find quantized rotational energy of a diatomic molecule assuming it to be rigid. The rule to be applied is Bohr's quantization condition. **(2010)**

Q 15. A diatomic molecule has moment of inertia I. By Bohr's quantization condition its rotational energy in the n^{th} level ($n = 0$ is not allowed) is

(A) $\frac{1}{n^2}\frac{h^2}{8\pi^2 I}$ (B) $\frac{1}{n}\frac{h^2}{8\pi^2 I}$ (C) $n\frac{h^2}{8\pi^2 I}$ (D) $n^2\frac{h^2}{8\pi^2 I}$

Q 16. It is found that the excitation frequency from ground to the first excited state of rotation for the CO molecule is close to $\frac{4}{\pi} \times 10^{11}$ Hz. Then the moment of inertia of CO molecule about its centre of mass is close to [Take $h = 2\pi \times 10^{-34}$ J s.]

(A) 2.76×10^{-46} kg m^2 (B) 1.87×10^{-46} kg m^2
(C) 4.67×10^{-47} kg m^2 (D) 1.17×10^{-47} kg m^2

Q 17. In CO molecule, the distance between C (mass = 12 u) and O (mass = 16 u), where 1 u = $\frac{5}{3} \times 10^{-27}$ kg, is close to

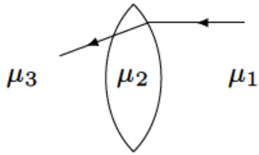
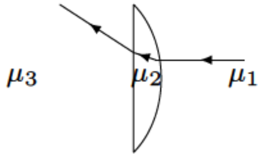
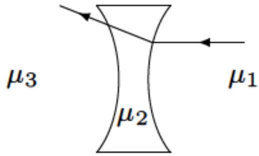
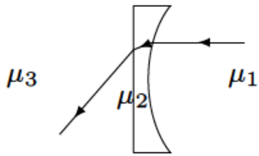
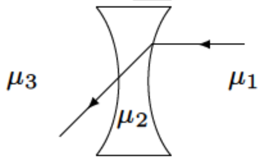
(A) 2.4×10^{-10} m (B) 1.9×10^{-10} m
(C) 1.3×10^{-10} m (D) 4.4×10^{-11} m

Matrix or Matching Type

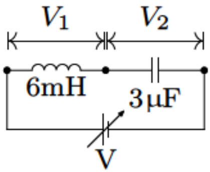
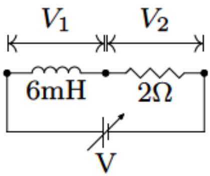
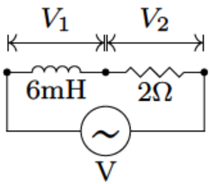
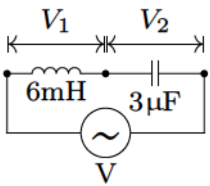
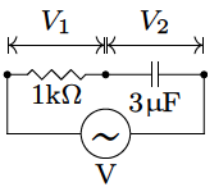
This section contains two questions. Each question contains two columns, column I and column II. Column I has four entries (A), (B), (C) and (D). Column II has five entries (p), (q), (r), (s) and (t). Match the entries in column I with entries in column II. Any given statement in column I can have correct matching with one or more statement(s) given in column II. For each entry in column I, darken the bubbles of all the matching entries. For example, if entry (A) in column I matches with entries (q), (r) and (t), then darken these three bubbles. Similarly, for entries (B), (C) and (D). Marking scheme for each entry in column I is:

1. Full Marks: (+2) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

Q 18. Two transparent media of refractive indices μ_1 and μ_3 have a solid lens shaped transparent material of refractive index μ_2 between them as shown in figures in *Column II*. A ray traversing these media is also shown in the figures. In *Column I* different relationship between μ_1, μ_2 and μ_3 are given. Match them to the ray diagrams shown in *Column II*.

Column I	Column II
(A) $\mu_1 < \mu_2$	(p) 
(B) $\mu_1 > \mu_2$	(q) 
(C) $\mu_2 = \mu_3$	(r) 
(D) $\mu_2 > \mu_3$	(s) 
	(t) 

Q 19. You are given many resistances, capacitors and inductors. These are connected to variable DC voltage source (the first two circuits) or an AC voltage source of 50 Hz frequency (the next three circuits) in different ways as shown in *Column II*. When a current (steady state for DC or *rms* for AC) flows through the circuit, the corresponding votage V_1 and V_2 (indicated in circuits) are related as shown in *Column I*. Match the two,

Column I	Column II
(A) $I \neq 0,\ V_1 \propto I$	(p) 
(B) $I \neq 0, V_2 > V_1$	(q) 
(C) $V_1 = 0, V_2 = V$	(r) 
(D) $I \neq 0,\ V_2 \propto I$	(s) 
	(t) 

Answers

1. D
2. B
3. B
4. C
5. D
6. A
7. 4
8. 2
9. 3
10. 6
11. 8
12. C
13. A
14. B
15. D
16. B
17. C
18. A$\mapsto$(p,r), B$\mapsto$(q,s,t), C$\mapsto$(p,r,t), D$\mapsto$(q,s)
19. A$\mapsto$(r,s,t), B$\mapsto$(q,r,s,t), C$\mapsto$(p,q), D$\mapsto$(q,r,s,t)

IIT JEE 2009

IIT JEE 2009 was a single stage examination of two papers, Paper 1 and Paper 2, each of three hours duration. Each of the papers has three separate sections of physics, chemistry and mathematics. All questions were of objective type, designed to test comprehension, reasoning and analytical ability of the candidate.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper 1

The physics part of the paper contains 20 questions. The questions are divided into four sections (1) single correct answer type (2) multiple correct answers type (3) paragraph type and (4) matrix-matching type.

One Option Correct

This section contains 8 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 1. Three concentric metallic spherical shells of radii R, $2R$ and $3R$, are given charges Q_1, Q_2 and Q_3, respectively. It is found that the surface charge densities on the outer surfaces of the shells are equal. Then, the ratio of the charges given to the shells, $Q_1 : Q_2 : Q_3$, is

(A) $1:2:3$ (B) $1:3:5$ (C) $1:4:9$ (D) $1:8:18$

Q 2. A block of base 10 cm $\times$ 10 cm and height 15 cm is kept on an inclined plane. The coefficient of friction between them is $\sqrt{3}$. The inclination θ of this inclined plane from the horizontal plane is gradually increased from $0°$. Then,

(A) at $\theta = 30°$, the block will start sliding down the plane.

(B) the block will remain at rest on the plane up to certain θ and then it will topple.

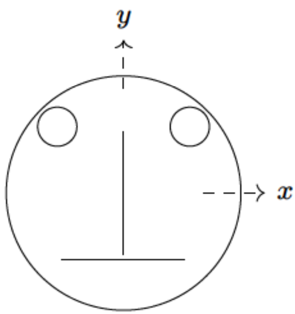
(C) at $\theta = 60°$, the block will start sliding down the plane and continue to do so at higher angles.

(D) at $\theta = 60°$, the block will start sliding down the plane and on further increasing θ, it will topple at certain θ.

Q 3. A ball is dropped from a height of 20 m above the surface of water in a lake. The refractive index of water is 4/3. A fish inside the lake, in the line of fall of the ball, is looking at the ball. At an instant, when the ball is 12.8 m above the water surface, the fish sees the speed of ball as [Take $g = 10\ \mathrm{m/s^2}$.]

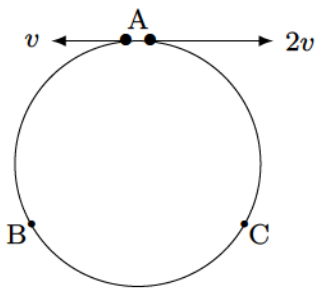
(A) 9 m/s (B) 12 m/s (C) 16 m/s (D) 21.33 m/s

Q 4. Look at the drawing given in the figure which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m. The mass of the ink used to draw the outer circle is $6m$. The coordinates of the centres of the different parts are: outer circle $(0, 0)$, left inner circle $(-a, a)$, right inner circle (a, a), vertical line $(0, 0)$ and horizontal line $(0, -a)$. The y-coordinate of the centre of mass of the ink in this drawing is



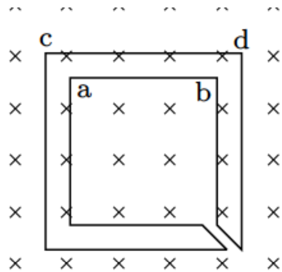
(A) $a/10$ (B) $a/8$ (C) $a/12$ (D) $a/3$

Q 5. Two small particles of equal masses start moving in opposite directions from a point A in a horizontal circular orbit. Their tangential velocities are v and $2v$, respectively, as shown in the figure. Between collisions, the particles move with constant speeds. After making how many elastic collisions, other than that at A, these two particles will again reach the point A?



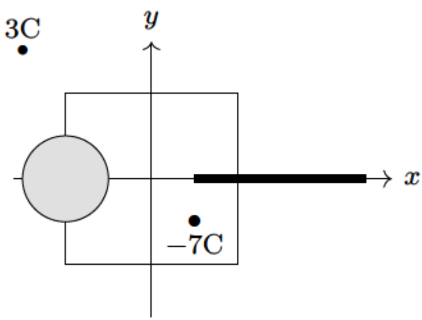
(A) 4 (B) 3 (C) 2 (D) 1

Q 6. The figure shows certain wire segments joined together to form a coplanar loop. The loop is placed in a perpendicular magnetic field in the direction going into the plane of the figure. The magnitude of the field increases with time. I_1 and I_2 are the currents in the segments **ab** and **cd**. Then,



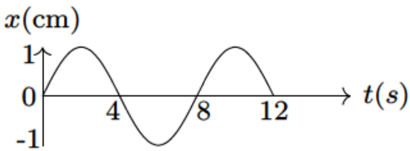
(A) $I_1 > I_2$
(B) $I_1 < I_2$
(C) I_1 is in the direction **ba** and I_2 is in the direction **cd**
(D) I_1 is in the direction **ab** and I_2 is in the direction **dc**

Q 7. A disc of radius $a/4$ having a uniformly distributed charge 6 C is placed in the x-y plane with its center at $(-a/2, 0, 0)$. A rod of length a carrying a uniformly distributed charge 8 C is placed on the x-axis from $x = a/4$ to $x = 5a/4$. The two point charges -7 C and 3 C are placed at $(a/4, -a/4, 0)$ and $(-3a/4, 3a/4, 0)$, respectively. Consider a cubical surface formed by six surfaces $x = \pm a/2$, $y = \pm a/2$, $z = \pm a/2$. The electric flux through the cubical surface is



(A) $-\frac{2C}{\epsilon_0}$ (B) $\frac{2C}{\epsilon_0}$ (C) $\frac{10C}{\epsilon_0}$ (D) $\frac{12C}{\epsilon_0}$

Q 8. The x-t graph of a particle undergoing SHM is shown in the figure. The acceleration of the particle at $t = 4/3$ s is



(A) $\frac{\sqrt{3}}{32}\pi^2$ cm/s^2 (B) $\frac{-\pi^2}{32}$ cm/s^2

(C) $\frac{\pi^2}{32}$ cm/s^2 (D) $-\frac{\sqrt{3}}{32}\pi^2$ cm/s^2

One or More Option(s) Correct

This section has 4 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: −1 In all other cases

Q 9. If the resultant of all the external forces acting on a system of particles is zero, then from an inertial frame, one can surely say that,

(A) linear momentum of the system does not change in time.

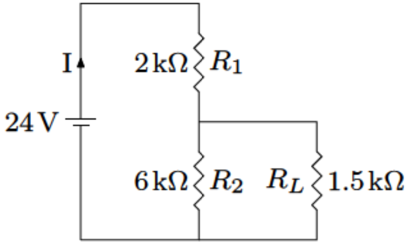
(B) kinetic energy of the system does not change in time.

(C) angular momentum of the system does not change in time.

(D) potential energy of the system does not change in time.

Q 10. A student performed the experiment for determination of focal length of a concave mirror by using u-v method using an optical bench of length 1.5 m. The focal length of the mirror used is 24 cm. The maximum error in the location of the image can be 0.2 cm. The 5 sets of (u, v) values recorded by the student (in cm) are: $(42, 56)$, $(48, 48)$, $(60, 40)$, $(66, 33)$ and $(78, 39)$. The data set(s) that *cannot* come from experiment and is (are) incorrectly recorded, is (are)
(A) $(42, 56)$ (B) $(48, 48)$ (C) $(66, 33)$ (D) $(78, 39)$

Q 11. For the circuit shown in the figure,



(A) the current I through the battery is 7.5 mA.
(B) the potential difference across R_L is 18 V.
(C) ratio of powers dissipated in R_1 and R_2 is 3.
(D) if R_1 and R_2 are interchanged, magnitude of the power dissipated in R_L will decrease by a factor of 9.

Q 12. C_v and C_p denotes the molar specific heat capacities of a gas at constant volume and constant pressure, respectively. Then,

(A) $C_p - C_v$ is larger for a diatomic ideal gas than for a monatomic ideal gas.

(B) $C_p + C_v$ is larger for a diatomic ideal gas than for a monatomic ideal gas.

(C) C_p / C_v is larger for a diatomic ideal gas than for a monatomic ideal gas.

(D) $C_p \cdot C_v$ is larger for a diatomic ideal gas than for a monatomic ideal gas.

Paragraph Type

This section contains 6 questions based on two paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 13-15

Scientists are working hard to develop nuclear fusion reactor. Nuclei of heavy hydrogen, ${}_1^2$H, known as deuteron and denoted by D, can be thought of as a candidate for fusion reactor. The D-D reaction is ${}_1^2\mathrm{H} + {}_1^2\mathrm{H} \rightarrow {}_2^3\mathrm{He} + n +$ energy. In the core of fusion reactor, a gas of heavy hydrogen is fully ionized into deuteron nuclei and electrons. This collection of ${}_1^2$H nuclei and electrons is known as plasma. The nuclei move randomly in the reactor core and occasionally come close enough for nuclear fusion to take place. Usually, the temperatures in the reactor core are too high and no material wall can be used to confine the plasma. Special techniques are used which confine the plasma for a time t_0 before the particles fly away from the core. If n is the density (number/volume) of deuterons, the product nt_0 is called Lawson number. In one of the criteria, a reactor is termed successful if Lawson number is greater than 5×10^{14} g/cm^3. [Given Boltzmann constant $k = 8.6 \times 10^{-5}$ eV/K, $\frac{e^2}{4\pi\epsilon_0} = 1.44 \times 10^{-9}$ eV m.]

(2009)

Q 13. In the core of nuclear fusion reactor, the gas becomes plasma because of

(A) strong nuclear force acting between the deuterons.

(B) Coulomb force acting between deuterons.

(C) Coulomb force acting between deuteron-electron pairs.

(D) the high temperature maintained inside the reactor core.

Q 14. Assume that two deuteron nuclei in the core of fusion reactor at temperature T are moving towards each other, each with kinetic energy $1.5kT$, when the separation between them is large enough to neglect Coulomb potential energy. Also neglect any interaction from other particles in the core. The minimum temperature T required for them to reach a separation of 4×10^{-15} m is in the range

(A) 1.0×10^9 K $< T < 2.0 \times 10^9$ K
(B) 2.0×10^9 K $< T < 3.0 \times 10^9$ K
(C) 3.0×10^9 K $< T < 4.0 \times 10^9$ K
(D) 4.0×10^9 K $< T < 5.0 \times 10^9$ K

Q 15. Results of calculations for four different designs of a fusion reactor using D-D reaction are given below. Which of these is most promising based on Lawson criterion?

(A) deuteron density$=2.0 \times 10^{12}\ \mathrm{cm}^{-3}$, confinement time$=5.0 \times 10^{-3}$ s

(B) deuteron density$=8.0 \times 10^{14}\ \mathrm{cm}^{-3}$, confinement time$=9.0 \times 10^{-1}$ s

(C) deuteron density$=4.0 \times 10^{23}\ \mathrm{cm}^{-3}$, confinement time$=1.0 \times 10^{-11}$ s

(D) deuteron density$=1.0 \times 10^{24}\ \mathrm{cm}^{-3}$, confinement time$=4.0 \times 10^{-12}$ s

Paragraph for Questions 16-18

When a particle is restricted to move along x-axis between $x = 0$ and $x = a$, where a is of nanometer dimensions, its energy can take only certain specific values. The allowed energies of the particle moving in such a restricted region, correspond to the formation of standing waves with nodes at its ends $x = 0$ and $x = a$. The wavelength of this standing wave is related to the linear momentum p of the particle according to the de-Broglie relation. The energy of the particle of mass m is related to its linear momentum as $E = \frac{p^2}{2m}$. Thus, the energy of the particle can be denoted by a quantum number 'n' taking values $1, 2, 3, \ldots$ ($n = 1$ called the ground state) corresponding to the number of loops in the standing wave.

Use the model described above to answer the following three questions for a particle moving in the line $x = 0$ to $x = a$. [Take $h = 6.6 \times 10^{-34}$ J s and $e = 1.6 \times 10^{-19}$ C.] (2009)

Q 16. The allowed energy for the particle for a particular value of n is proportional to
(A) a^{-2} (B) $a^{-3/2}$ (C) a^{-1} (D) a^{2}

Q 17. If the mass of the particle is $m = 1.0 \times 10^{-30}$ kg and $a = 6.6$ nm, the energy of the particle in its ground state is closest to
(A) 0.8 meV (B) 8 meV (C) 80 meV (D) 800 meV

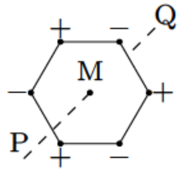
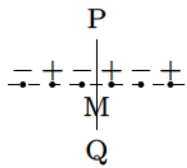
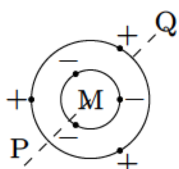
Q 18. The speed of the particle, that can take discrete values, is proportional to
(A) $n^{-3/2}$ (B) n^{-1} (C) $n^{1/2}$ (D) n

Matrix or Matching Type

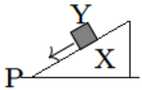
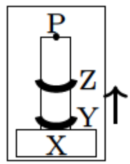
This section contains two questions. Each question contains two columns, column I and column II. Column I has four entries (A), (B), (C) and (D). Column II has five entries (p), (q), (r), (s) and (t). Match the entries in column I with entries in column II. Any given statement in column I can have correct matching with one or more statement(s) given in column II. For each entry in column I, darken the bubbles of all the matching entries. For example, if entry (A) in column I matches with entries (q), (r) and (t), then darken these three bubbles. Similarly, for entries (B), (C) and (D). Marking scheme for each entry in column I is:

1. Full Marks: (+2) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

Q 19. Six point charges, each of the same magnitude q, are arranged in different manners as shown in *Column II.* In each case, a point M and a line PQ passing through M are shown. Let E be the electric field and V be the electric potential at M (potential at infinity is zero) due to the given charge distribution when it is at rest. Now, the whole system is set into rotation with a constant angular velocity about the line PQ. Let B be the magnetic field at M and μ be the magnetic moment of the system in this condition. Assume each rotating charge to be equivalent to a steady current.

<table>
<tr><th>Column I</th><th>Column II</th></tr>
<tr><td>(A) $E = 0$</td><td>(p) Charges are at the corners of a regular hexagon. M is at the centre of the hexagon and PQ is perpendicular to the plane of the hexagon.

</td></tr>
<tr><td>(B) $V \neq 0$</td><td>(q) Charges are on a line perpendicular to PQ at equal intervals, M is the mid-point between the two innermost charges.

</td></tr>
<tr><td>(C) $B = 0$</td><td>(r) Charges are placed on two coplanar insulating rings at equal intervals. M is the common centre of the ring. PQ is perpendicular to the plane of the rings.

</td></tr>
</table>

Q 20. *Column II* shows five systems in which two objects are labelled as X and Y. Also in each case a point P is shown. *Column I* gives some statements about X and/or Y. Match these statements to the appropriate system(s) from *Column II*.

Column I	Column II
(A) The force exerted by X on Y has a magnitude Mg.	(p) Block Y of mass M left on a fixed inclined plane X, slides on it with a constant velocity. 
(B) The gravitational potential energy of X is continuously increasing.	(q) The ring magnets Y and Z, each of mass M, are kept in frictionless vertical plastic stand so that they repel each other. Y rests on the base X and Z hangs in air in equilibrium. P is the topmost point of the stand on the common axis of the two rings. The whole system is in a lift that is going up with a constant velocity. 
(C) Mechanical energy of the system $X + Y$ is	(r) A pulley Y of mass m_0 is fixed to a table through a clamp X. A block of mass M hangs from a string that goes

Answers

1. B
2. B
3. C
4. A
5. C
6. D
7. A
8. D
9. A
10. C, D
11. A, D
12. B, D
13. D
14. A
15. B
16. A
17. B
18. D
19. A$\mapsto$(p,r,s), B$\mapsto$(r,s), C$\mapsto$(p,q,t), D$\mapsto$(r,s)
20. A$\mapsto$(p,t), B$\mapsto$(q,s,t), C$\mapsto$(p,r,t), D$\mapsto$q

Paper 2

The physics part of the paper contains 19 questions. The questions are divided into four sections (1) single correct answer type (2) multiple correct answers type (3) integer type and (4) matrix-matching type.

One Option Correct

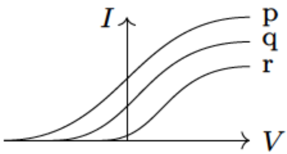
This section contains 4 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

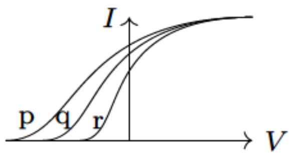
1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

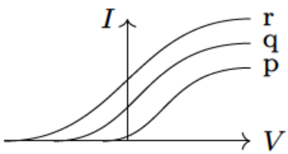
Q 1. A piece of wire is bent in the shape of a parabola $y = kx^2$ (y-axis vertical) with a bead of mass m on it. The bead can slide on the wire without friction. It stays at the lowest point of the parabola when the wire is at rest. The wire is now accelerated parallel to the x-axis with a constant acceleration a. The distance of the new equilibrium position of the bead, where the bead can stay at rest with respect to the wire, from the y-axis is

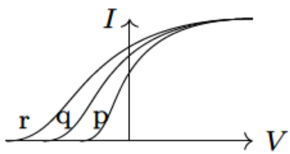
(A) $\frac{a}{gk}$ (B) $\frac{a}{2gk}$ (C) $\frac{2a}{gk}$ (D) $\frac{a}{4gk}$

Q 2. Photoelectric effect experiments are performed using three metal plates p, q and r having work functions $\phi_p = 2.0\,\text{eV}$, $\phi_q = 2.5\,\text{eV}$ and $\phi_r = 3.0\,\text{eV}$, respectively. A light beam containing wavelengths of 550 nm, 450 nm and 350 nm with equal intensities illuminates each of the plates. The correct I-V graph for the experiment is [Take $hc = 1240$ eV-nm.]

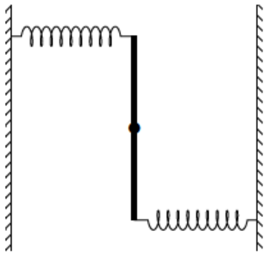
(A)


(B)


(C)


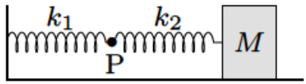
(D)


Q 3. A uniform rod of length L and mass M is pivoted at the centre. Its two ends are attached to two springs of equal spring constants k. The springs are fixed to rigid supports as shown in the figure, and the rod is free to oscillate in the horizontal plane. The rod is gently pushed through a small angle θ in one direction and released. The frequency of oscillation is



(A) $\frac{1}{2\pi}\sqrt{\frac{2k}{M}}$ (B) $\frac{1}{2\pi}\sqrt{\frac{k}{M}}$ (C) $\frac{1}{2\pi}\sqrt{\frac{6k}{M}}$ (D) $\frac{1}{2\pi}\sqrt{\frac{24k}{M}}$

Q 4. The mass M shown in the figure oscillates in SHM with amplitude A. The amplitude of the point P is



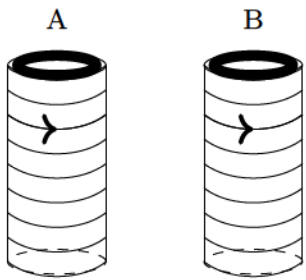
(A) $\frac{k_1 A}{k_2}$ (B) $\frac{k_2 A}{k_1}$ (C) $\frac{k_1 A}{k_1+k_2}$ (D) $\frac{k_2 A}{k_1+k_2}$

One or More Option(s) Correct

This section contains 5 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) In all other cases

Q 5. Two metallic rings A and B, identical in shape and size but having different resistivities ρ_A and ρ_B, are kept on top of two identical solenoids as shown in the figure. When current I is switched on in both the solenoids in identical manner, the rings A and B jumps to heights h_A and h_B, respectively, with $h_A > h_B$. The possible relation(s) between their resistivities and their masses m_A and m_B is (are)



(A) $\rho_A > \rho_B$ and $m_A = m_B$
(B) $\rho_A < \rho_B$ and $m_A = m_B$
(C) $\rho_A > \rho_B$ and $m_A > m_B$
(D) $\rho_A < \rho_B$ and $m_A < m_B$

Q 6. A student performed the experiment to measure the speed of sound in air using resonance air-column method. Two resonances in the air-column were obtained by lowering the water level. The resonance with the shorter air-column is the first resonance and that with the longer air-column is the second resonance. Then,

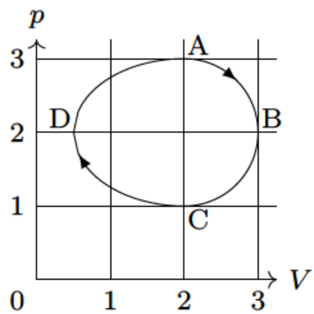
(A) the intensity of the sound heard at the first resonance was more than that at the second resonance.

(B) the prongs of the tuning fork were kept in a horizontal plane above the resonance tube.

(C) the amplitude of vibration of the ends of the prongs is typically around 1 cm.

(D) the length of the air-column at the first resonance was somewhat shorter than $1/4$ th of the wavelength of the sound in air.

Q 7. The figure shows the p-V plot of an ideal gas taken through a cycle ABCDA. The part ABC is a semi-circle and CDA is half of an ellipse. Then,



(A) the process during the path $A \to B$ is isothermal.

(B) heat flows out of the gas during the path $B \to C \to D$.

(C) work done during the path $A \to B \to C$ is zero.

(D) positive work is done by the gas in the cycle ABCDA.

Q 8. Under the influence of the Coulomb field of charge $+Q$, a charge $-q$ is moving around it in an elliptical orbit. Find out the correct statement(s).

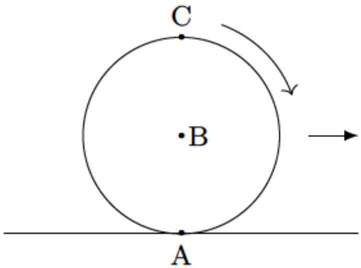
(A) The angular momentum of the charge $-q$ is constant.

(B) The linear momentum of the charge $-q$ is constant.

(C) The angular velocity of the charge $-q$ is constant.

(D) The linear speed of the charge $-q$ is constant.

Q 9. A sphere is rolling without slipping on a fixed horizontal plane surface. In the figure, A is the point of contact, B is the centre of the sphere and C is the topmost point. Then,



(A) $\vec{V}_C - \vec{V}_A = 2(\vec{V}_B - \vec{V}_C)$
(B) $\vec{V}_C - \vec{V}_B = \vec{V}_B - \vec{V}_A$
(C) $|\vec{V}_C - \vec{V}_A| = 2\,|\vec{V}_B - \vec{V}_C|$
(D) $|\vec{V}_C - \vec{V}_A| = 4\,|\vec{V}_B|$

Integer Type

This section has 8 questions. The answer to each question in this section is a single digit integer ranging from 0 to 9, both inclusive. Marking scheme is:

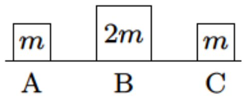
1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 10. A metal rod AB of length $10x$ has its one end A in ice at 0 °C and the other end B in water at 100 °C. If a point P on the rod is maintained at 400 °C, then it is found that equal amounts of water and ice evaporates and melts per unit time. The latent heat of evaporation of water is 540 cal/g and latent heat of melting of ice is 80 cal/g. If the point P is at a distance of λx from the ice end A, find the value of λ. [Neglect any heat loss to the surroundings.]

Q 11. A cylindrical vessel of height 500 mm has in orifice (small hole) at its bottom. The orifice is initially closed and water is filled in it up to height H. Now the top is completely sealed with a cap and the orifice at the bottom is opened. Some water comes out from the orifice and the water level in the vessel becomes steady with height of water column being 200 mm. Find the fall in height (in mm) of water level due to opening of the orifice. [Take atmospheric pressure $= 1.0 \times 10^5$ N/m^2, density of water $= 1000$ kg/m^3 and $g = 10$ m/s^2. Neglect any effect of surface tension.]

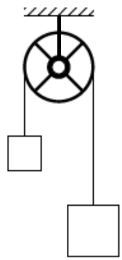
Q 12. Two soap bubbles A and B are kept in a closed chamber where the air is maintained at pressure $8\,\mathrm{N/m^2}$. The radii of bubbles A and B are $2\,\mathrm{cm}$ and $4\,\mathrm{cm}$, respectively. Surface tension of the soap-water used to make bubbles is $0.04\,\mathrm{N/m}$. Find the ratio n_B/n_A, where n_A and n_B are the number of moles of air in bubbles A and B, respectively. [Neglect the effect of gravity.]

Q 13. Three objects A, B and C are kept in a straight line on a frictionless horizontal surface. These have masses m, $2m$ and m, respectively. The object A moves towards B with a speed 9 m/s and makes an elastic collision with it. Thereafter, B makes completely inelastic collision with C. All motions occur on the same straight line. Find the final speed (in m/s) of the object C.



Q 14. A steady current I goes through a wire loop PQR having shape of a right angle triangle with PQ $= 3x$, PR $= 4x$ and QR $= 5x$. If the magnitude of the magnetic field at P due to this loop is $k\left(\frac{\mu_0 I}{48\pi x}\right)$, find the value of k.

Q 15. A light inextensible string that goes over a smooth fixed pulley as shown in the figure connects two blocks of masses 0.36 kg and 0.72 kg. Taking $g = 10\ \mathrm{m/s^2}$, find the work done (in joules) by the string on the block of mass 0.36 kg during the first second after the system is released from rest.



Q 16. A solid sphere of radius R has a charge Q distributed in its volume with a charge density $\rho = \kappa r^a$, where κ and a are constants and r is the distance from its centre. If the electric field at $r = R/2$ is $1/8$ times that at $r = R$, find the value of a.

Q 17. A 20 cm long string, having a mass of 1.0 g, is fixed at both the ends. The tension in the string is 0.5 N. The string is set into vibrations using an external vibrator of frequency 100 Hz. Find the separation (in cm) between the successive nodes on the string.

Matrix or Matching Type

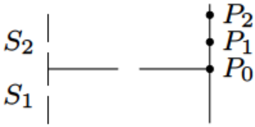
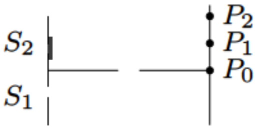
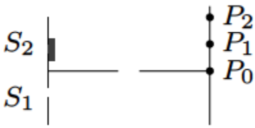
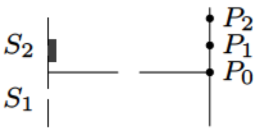
This section contains two questions. Each question contains two columns, column I and column II. Column I has four entries (A), (B), (C) and (D). Column II has five entries (p), (q), (r), (s) and (t). Match the entries in column I with entries in column II. Any given statement in column I can have correct matching with one or more statement(s) given in column II. For each entry in column I, darken the bubbles of all the matching entries. For example, if entry (A) in column I matches with entries (q), (r) and (t), then darken these three bubbles. Similarly, for entries (B), (C) and (D). Marking scheme for each entry in column I is:

1. Full Marks: (+2) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) In all other cases

Q 18. *Column II* gives certain systems undergoing a process. *Column I* suggests changes in some of the parameters related to the system. Match the statements in *Column I* to the appropriate process(es) from *Column II*.

Column I	Column II
(A) The energy of the system is increased.	(p) *System:* A capacitor, initially uncharged. *Process:* It is connected to a battery.
(B) Mechanical energy is provided to the system, which is converted into energy of random motion of its parts.	(q) *System:* A gas in an adiabatic container fitted with an adiabatic piston. *Process:* The gas is compressed by pushing the piston.
(C) Internal energy of the system is converted into its mechanical energy.	(r) *System:* A gas in a rigid container. *Process:* The gas gets cooled due to colder atmosphere surrounding it
(D) Mass of the system is decreased.	(s) *System:* A heavy nucleus, initially at rest. *Process:* The nucleus fissions into two fragments of nearly equal masses and some neutrons are emit-

Q 19. *Column I* shows four situations of standard Young's double slit arrangement with the screen placed far away from the slits S_1 and S_2. In each of these cases $\mathrm{S_1P_0} = \mathrm{S_2P_0}$, $\mathrm{S_1P_1} - \mathrm{S_2P_1} = \lambda/4$ and $\mathrm{S_1P_2} - \mathrm{S_2P_2} = \lambda/3$, where λ is the wavelength of the light used. In the case B, C, and D, a transparent sheet of refractive index μ and thickness t is pasted on slit S_2. The thicknesses of the sheets are different in different cases. The phase difference between the light waves reaching a point P on the screen from the two slits is denoted by $\delta(P)$ and the intensity by $I(P)$. Match each situation given in *Column I* with the statement(s) in *Column II* valid for that situation.

Column I	Column II
(A) 	(p) $\delta(P_0) = 0$
(B) $(\mu - 1)t = \lambda/4$ 	(q) $\delta(P_1) = 0$
(C) $(\mu - 1)t = \lambda/2$ 	(r) $I(P_1) = 0$
(D) $(\mu - 1)t = 3\lambda/4$ 	(s) $I(P_0) > I(P_1)$
	(t) $I(P_2) > I(P_1)$

Answers

1. B
2. A
3. C
4. D
5. B, D
6. A, D
7. B, D
8. A
9. B, C
10. 9
11. 6
12. 6
13. 4
14. 7
15. 8
16. 2
17. 5
18. A$\mapsto$(p,q,t), B$\mapsto$q, C$\mapsto$s, D$\mapsto$s
19. A$\mapsto$(p,s), B$\mapsto$q, C$\mapsto$t, D$\mapsto$(r,s,t)

IIT JEE 2008

IIT JEE 2008 was a single stage examination of two papers, Paper 1 and Paper 2, each of three hours duration. Each of the papers has three separate sections of physics, chemistry and mathematics. All questions were of objective type, designed to test comprehension, reasoning and analytical ability of the candidate.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper 1

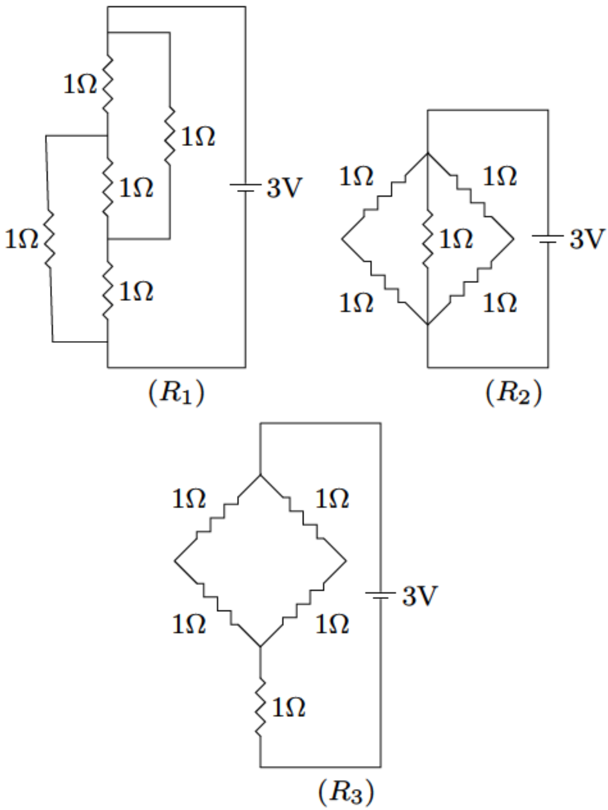
The physics part of the paper contains 23 questions. The questions are divided into four sections (1) single correct answer type (2) multiple correct answers type (3) assertion reasoning type and (4) paragraph type.

One Option Correct

Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: −1 In all other cases

Q 1. Figure shows three resistor configurations (R_1), (R_2), and (R_3) each connected to 3 V battery. If the power dissipated by the configuration (R_1), (R_2) and (R_3) is P_1, P_2 and P_3, respectively, then



(A) $P_1 > P_2 > P_3$ (B) $P_1 > P_3 > P_2$
(C) $P_2 > P_1 > P_3$ (D) $P_3 > P_2 > P_1$

Q 2. Which of the following statements is *wrong* in the context of X-rays generated from a X-ray tube?

(A) Wavelength of characteristic X-rays decreases when the atomic number of the target increases.

(B) Cut-off wavelength of the continuous X-rays depends on the atomic number of the target.

(C) Intensity of the characteristic X-rays depends on the electrical power given to the X-ray tube.

(D) Cut-off wavelength of the continuous X-rays depends on the energy of the electrons in the X-ray tube.

Q 3. Two beams of red and violet colours are made to pass separately through a prism (angle of the prism is $60°$). In the position of minimum deviation, the angle of refraction will be

(A) $30°$ for both the colours.

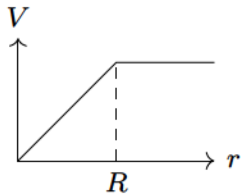
(B) greater for the violet colour.

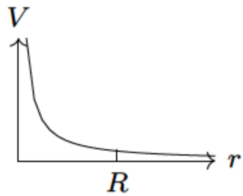
(C) greater for the red colour.

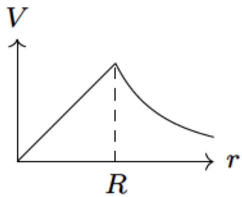
(D) equal but not $30°$ for both the colours.

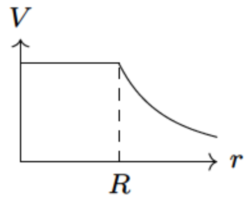
Q 4. An ideal gas is expanding such that $PT^2 =$ constant. The coefficient of volume expansion of the gas is
(A) $1/T$ (B) $2/T$ (C) $3/T$ (D) $4/T$

Q 5. A spherically symmetric gravitational system of particles has a mass density $\rho = \begin{cases} \rho_0 & \text{for } r \leq R \\ 0 & \text{for } r > R \end{cases}$, where ρ_0 is a constant. A test mass can undergo circular motion under the influence of the gravitational field of particles. Its speed V as a function of distance $r\,(0 < r < \infty)$ from the centre of the system is represented by

(A)


(B)


(C)


(D)


Q 6. Students I, II and III perform an experiment for measuring the acceleration due to gravity (g) using a simple pendulum. They use different lengths of the pendulum and/or record time for different number of oscillations. The observations are shown in the table. The least count for length is 0.1 cm and least count for time is 0.1 s.

Student	Length of pendulum (cm)	No. of oscillations (n)	Time for (n) oscillations (s)	Time period (s)
I	64.0	8	128.0	16.0
II	64.0	4	64.0	16.0
III	20.0	4	36.0	9.0

If E_{I}, E_{II} and E_{III} are the percentage errors in g i.e., $\left(\frac{\Delta g}{g} \times 100\right)$ for students I, II and III, respectively,

(A) $E_{\mathrm{I}} = 0$ (B) E_{I} is minimum

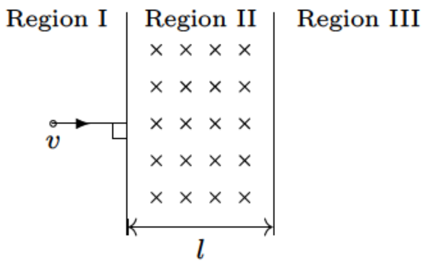
(C) $E_{\mathrm{I}} = E_{\mathrm{II}}$ (D) E_{II} is maximum

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four options is (are) correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened

Q 7. A particle of mass m and charge q, moving with velocity v enters Region II to the boundary as shown in the figure. Region II has a uniform magnetic field B perpendicular to the plane of the paper. The length of the region II is l. Choose the correct choice(s).



(A) The particle enters region III only if its velocity $v > qlB/m$.

(B) The particle enters region III only if its velocity $v < qlB/m$.

(C) Path length of the particle in Region II is maximum when $v = qlB/m$.

(D) Time spent in Region II is same for any velocity v as long as the particle returns to Region I.

Q 8. In a Young's double slit experiment, the separation between the two slits is d and the wavelength of the light is λ. The intensity of light falling on the slit 1 is four times the intensity of light falling on slit 2. Choose the correct option(s),

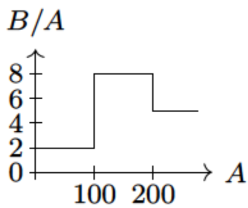
(A) If $d = \lambda$, the screen will contain only one maximum.

(B) If $\lambda < d < 2\lambda$, at least one more maximum (besides the central maximum) will be observed on the screen.

(C) If the intensity of light falling on slit 1 is reduced so that it becomes equal to that of slit 2, the intensities of the observed dark and bright fringes will increase.

(D) If the intensity of light falling on slit 2 is increased so that it becomes equal to that of slit 1, the intensities of the observed dark and bright fringes will increase.

Q 9. Assume that the nuclear binding energy per nucleon (B/A) *versus* mass number (A) is as shown in the figure. Use this plot to choose the correct choice(s) given below.



(A) Fusion of two nuclei with mass number lying in the range of $1 < A < 50$ will release energy.

(B) Fusion of two nuclei with mass number lying in the range of $51 < A < 100$ will release energy.

(C) Fission of a nucleus lying in the mass range of $100 < A < 200$ will release energy when broken into two equal fragments.

(D) Fission of a nucleus lying in the mass range of $200 < A < 260$ will release energy when broken into two equal fragments.

Q 10. Two balls, having linear momenta $\vec{p}_1 = p\,\hat{\imath}$ and $\vec{p}_2 = -p\,\hat{\imath}$, undergo a collision in free space. There is no external force acting on the balls. Let $\vec{p}_1'$ and $\vec{p}_2'$ be their final momenta. The following option(s) is (are) not allowed for any non-zero value of $p, a_1, a_2, b_1, b_2, c_1$ and c_2.

(A) $\vec{p}_1' = a_1\hat{\imath} + b_1\hat{\jmath} + c_1\hat{k}$, $\vec{p}_2' = a_2\hat{\imath} + b_2\hat{\jmath}$
(B) $\vec{p}_1' = c_1\hat{k}$, $\vec{p}_2' = c_2\hat{k}$
(C) $\vec{p}_1' = a_1\hat{\imath} + b_1\hat{\jmath} + c_1\hat{k}$, $\vec{p}_2' = a_2\hat{\imath} + b_2\hat{\jmath} - c_1\hat{k}$
(D) $\vec{p}_1' = a_1\hat{\imath} + b_1\hat{\jmath}$, $\vec{p}_2' = a_2\hat{\imath} + b_1\hat{\jmath}$

Paragraph Type

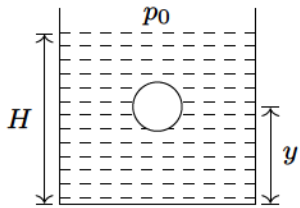
This section contains 9 questions based on three paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 11-13

A small spherical monatomic ideal gas bubble ($\gamma = 5/3$) is trapped inside a liquid of density ρ_l (see figure). Assume that the bubble does not exchange any heat with the liquid. The bubble contains n moles of gas. The temperature of the gas when the bubble is at the bottom is T_0, the height of the liquid is H and the atmospheric pressure is p_0. [Neglect surface tension.]

(2008)



Q 11. As the bubble moves upwards, besides the buoyancy force the following forces are acting on it,

(A) Only the force of gravity.

(B) The force due to gravity and the force due to the pressure of the liquid.

(C) The force due to gravity, the force due to the pressure of the liquid and the force due to viscosity of the liquid.

(D) The force due to gravity and the force due to viscosity of the liquid.

Q 12. When the gas bubble is at a height y from the bottom, its temperature is

(A) $T_0\left(\frac{p_0+\rho_l gH}{p_0+\rho_l gy}\right)^{2/5}$ (B) $T_0\left(\frac{p_0+\rho_l g(H-y)}{p_0+\rho_l gH}\right)^{2/5}$

(C) $T_0\left(\frac{p_0+\rho_l gH}{p_0+\rho_l gy}\right)^{3/5}$ (D) $T_0\left(\frac{p_0+\rho_l g(H-y)}{p_0+\rho_l gH}\right)^{3/5}$

Q 13. The buoyancy force acting on the gas bubble is [Here R is the universal gas constant.]

(A) $\rho_l nRgT_0 \frac{(p_0+\rho_l gH)^{2/5}}{(p_0+\rho_l gy)^{7/5}}$

(B) $\frac{\rho_l nRgT_0}{(p_0+\rho_l gH)^{2/5}[p_0+\rho_l g(H-y)]^{3/5}}$

(C) $\rho_l nRgT_0 \frac{(p_0+\rho_l gH)^{3/5}}{(p_0+\rho_l gy)^{8/5}}$

(D) $\frac{\rho_l nRgT_0}{(p_0+\rho_l gH)^{3/5}[p_0+\rho_l g(H-y)]^{2/5}}$

Paragraph for Questions 14-16

In a mixture of H-He^+ gas (He^+ is singly ionized He atom), H atoms and He^+ ions are excited to their respective first excited states. Subsequently, H atoms transfer their total excitation energy to He^+ ions (by collisions). Assume that the Bohr model of atom is exactly valid. (2008)

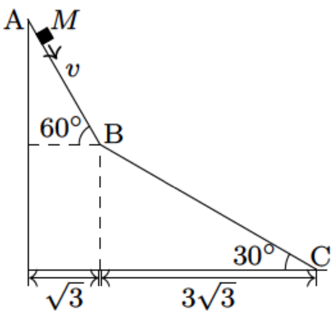
Q 14. The quantum number n of the state finally populated in He^+ ion is
(A) 2 (B) 3 (C) 4 (D) 5

Q 15. The wavelength of light emitted in the visible region by He^+ ion after collisions with H atom is
(A) 6.5×10^{-7} m (B) 5.6×10^{-7} m
(C) 4.8×10^{-7} m (D) 4.0×10^{-7} m

Q 16. The ratio of the kinetic energy of the $n = 2$ electron for the H atom to that of He^+ ion is
(A) 1/4 (B) 1/2 (C) 1 (D) 2

Paragraph for Questions 17-19

A small block of mass M moves on a frictionless surface of an inclined plane, as shown in the figure. The angle of the incline suddenly change from $60°$ to $30°$ at point B. The block is initially at rest at A. Assume that collisions between the block and the incline are totally inelastic. [Take $g = 10\ \mathrm{m/s^2}$.] (2008)



Q 17. The speed of the block at point B immediately after it strikes the second incline is
(A) $\sqrt{60}$ m/s (B) $\sqrt{45}$ m/s
(C) $\sqrt{30}$ m/s (D) $\sqrt{15}$ m/s

Q 18. The speed of the block at point C, immediately before it leaves the second incline is
(A) $\sqrt{120}$ m/s (B) $\sqrt{105}$ m/s
(C) $\sqrt{90}$ m/s (D) $\sqrt{75}$ m/s

Q 19. If collision between the block and the incline is completely elastic, then the vertical (upward) component of the velocity of the block at point B, immediately after it strikes the second incline is
(A) $\sqrt{30}$ m/s (B) $\sqrt{15}$ m/s (C) 0 (D) $-\sqrt{15}$ m/s

Assertion Reasoning Type

This section contains 4 reasoning type questions. Each question contains four options related to two statements, statement 1 and statement 2. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 20. *Statement 1:* In a metre bridge experiment, null point for an unknown resistance is measured. Now, the unknown resistance is put inside an enclosure maintained at a higher temperature. The null point can be obtained at the same point as before by decreasing the value of the standard resistance.

Statement 2: Resistance of a metal increase with increase in temperature.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.
(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.
(C) Statement 1 is true, statement 2 is false.
(D) Statement 1 is false, statement 2 is true.

Q 21. *Statement 1:* An astronaut in an orbiting space station above the Earth experiences weightlessness.

Statement 2: An object moving around the Earth under the influence of Earth's gravitational force is in a state of *free-fall*.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.

(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.

(C) Statement 1 is true, statement 2 is false.

(D) Statement 1 is false, statement 2 is true.

Q 22. *Statement 1:* Two cylinders, one hollow (metal) and the other solid (wood) with the same mass and identical dimensions are simultaneously allowed to roll without slipping down an inclined plane from the same height. The hollow cylinder will reach the bottom of the inclined plane first.

Statement 2: By the principle of conservation of energy, the total kinetic energies of both the cylinders are identical when they reach the bottom of the incline.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.
(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.
(C) Statement 1 is true, statement 2 is false.
(D) Statement 1 is false, statement 2 is true.

Q 23. *Statement 1:* The stream of water flowing at high speed from a garden hose pipe tends to spread like a fountain when held vertically up, but tends to narrow down when held vertically down.

Statement 2: In any steady flow of an incompressible fluid, the volume flow rate of the fluid remains constant.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.
(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.
(C) Statement 1 is true, statement 2 is false.
(D) Statement 1 is false, statement 2 is true.

Answers

1. C
2. B
3. A
4. C
5. C
6. B
7. A, C, D
8. A, B
9. B, D
10. A, D
11. D
12. B
13. B
14. C
15. C
16. A
17. B
18. B
19. C
20. D
21. A
22. D
23. A

Paper 2

The physics part of the paper contains 22 questions. The questions are divided into four sections (1) single correct answer type (2) matrix-matching type (3) assertion reasoning type and (4) paragraph type.

One Option Correct

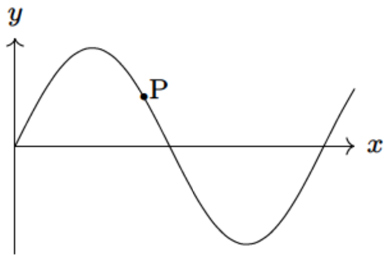
This section contains 9 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 1. A radioactive sample S_1 having an activity of 5 μCi has twice the number of nuclei as another sample S_2 which has an activity of 10 μCi. The half lives of S_1 and S_2 can be

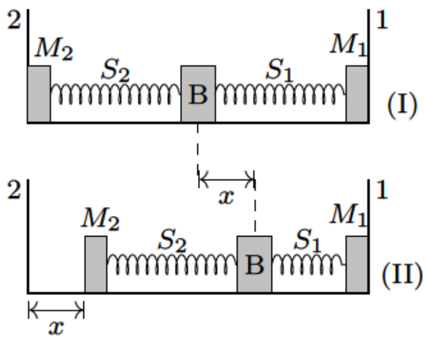
(A) 20 years and 5 years, respectively.
(B) 20 years and 10 years, respectively.
(C) 10 years each.
(D) 5 years each.

Q 2. A transverse sinusoidal wave moves along a string in the positive x direction at a speed of 10 cm/s. The wavelength of the wave is 0.5 m and its amplitude is 10 cm. At a particular time t, the snap-shot of the wave is shown in the figure. The velocity of point P when its displacement is 5 cm is



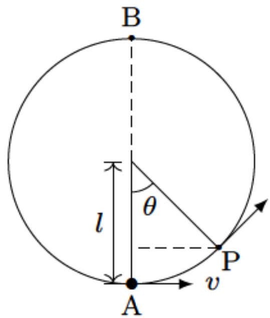
(A) $\frac{\sqrt{3}\pi}{50}\hat{\jmath}$ m/s (B) $-\frac{\sqrt{3}\pi}{50}\hat{\jmath}$ m/s
(C) $\frac{\sqrt{3}\pi}{50}\hat{\imath}$ m/s (D) $-\frac{\sqrt{3}\pi}{50}\hat{\imath}$ m/s

Q 3. A block B is attached to two unstretched springs S_1 and S_2 with spring constants k and $4k$, respectively (see figure I). The other ends are attached to identical supports M_1 and M_2, not attached to the walls. The springs and supports have negligible mass. There is no friction anywhere. The block B is displaced towards wall 1 by a small distance x (see figure II) and released. The block returns and moves a maximum distance y towards wall 2. Displacements x and y are measured with respect to the equilibrium position of the block B. The ratio y/x is



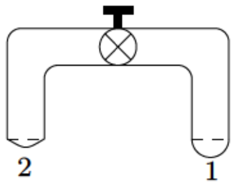
(A) 4 (B) 2 (C) 1/2 (D) 1/4

Q 4. A bob of mass m is suspended by a massless string of length l. The horizontal velocity v at position A is just sufficient to make it reach the point B. The angle θ at which the speed of the bob is half of that at A, satisfies,



(A) $\theta = \frac{\pi}{4}$ (B) $\frac{\pi}{4} < \theta < \frac{\pi}{2}$
(C) $\frac{\pi}{2} < \theta < \frac{3\pi}{4}$ (D) $\frac{3\pi}{4} < \theta < \pi$

Q 5. A glass tube of uniform internal radius r has a valve separating the two identical ends. Initially, the valve is in a tightly closed position. End 1 has a hemispherical soap bubble of radius r. End 2 has sub-hemispherical soap bubble as shown in the figure. Just after opening the valve,

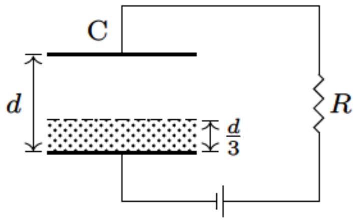


(A) air from end 1 flows towards end 2. No change in the volume of the soap bubbles.
(B) air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases.
(C) no change occurs.
(D) air from end 2 flows towards end 1. Volume of the soap bubble at end 1 increases.

Q 6. A vibrating string of certain length l under a tension T resonates with a mode corresponding to the first overtone (third harmonic) of an air column of length 75 cm inside a tube closed at one end. The string also generates 4 beats per second when excited along with a tuning fork of frequency n. Now when the tension of the string is slightly increased the number of beats reduces to 2 per second. Assuming the velocity of sound in air to be 340 m/s, the frequency n of the tuning fork (in Hz) is

(A) 344 (B) 336 (C) 117.3 (D) 109.3

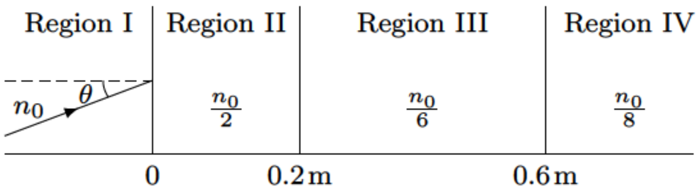
Q 7. A parallel plate capacitor C with plates of unit area and separation d is filled with a liquid of dielectric constant $K = 2$. The level of liquid is $d/3$ initially. Suppose the liquid level decreases at a constant speed V, the time constant as a function of time t is



(A) $\frac{6\epsilon_0 R}{5d+3Vt}$ (B) $\frac{(15d+9Vt)\epsilon_0 R}{2d^2-3dVt-9V^2t^2}$

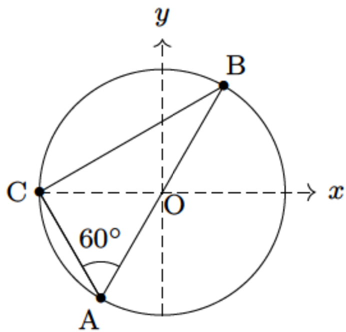
(C) $\frac{6\epsilon_0 R}{5d-3Vt}$ (D) $\frac{(15d-9Vt)\epsilon_0 R}{2d^2+3dVt-9V^2t^2}$

Q 8. A light beam is traveling from Region I to Region IV (see figure). The refractive index in Region I, II, III and IV are n_0, $\frac{n_0}{2}$, $\frac{n_0}{6}$ and $\frac{n_0}{8}$, respectively. The angle of incidence θ for which the beam just misses entering region IV is



(A) $\sin^{-1}\left(\frac{3}{4}\right)$ (B) $\sin^{-1}\left(\frac{1}{8}\right)$
(C) $\sin^{-1}\left(\frac{1}{4}\right)$ (D) $\sin^{-1}\left(\frac{1}{3}\right)$

Q 9. Consider a system of three charges $\frac{q}{3}$, $\frac{q}{3}$ and $-\frac{2q}{3}$ placed at points A, B and C, respectively, as shown in the figure. Take O to be the centre of the circle of radius R and angle CAB $= 60°$.



(A) The electric field at point O is $\frac{q}{8\pi\epsilon_0 R^2}$ directed along the negative x-axis.
(B) The potential energy of the system is zero.
(C) The magnitude of the force between the charge C and B is $\frac{q^2}{54\pi\epsilon_0 R^2}$.
(D) The potential at point O is $\frac{q}{12\pi\epsilon_0 R}$.

Assertion Reasoning Type

This section contains 4 reasoning type questions. Each question contains four options related to two statements, statement 1 and statement 2. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 10. *Statement 1:* For an observer looking out through the window of a fast moving train, the nearby objects appear to move in the opposite direction to the train, while the distant objects appear to be stationary.

Statement 2: If the observer and the object are moving at velocities $\vec{V}_1$ and $\vec{V}_2$ respectively with reference to a laboratory frame, the velocity of the object with respect to the observer is $\vec{V}_2 - \vec{V}_1$.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.

(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.

(C) Statement 1 is true, statement 2 is false.

(D) Statement 1 is false, statement 2 is true.

Q 11. *Statement 1:* The sensitivity of a moving coil galvanometer is increased by placing a suitable magnetic material as core inside the coil.

Statement 2: Soft iron has a high magnetic permeability and cannot be easily magnetized or demagnetized.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.

(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.

(C) Statement 1 is true, statement 2 is false.

(D) Statement 1 is false, statement 2 is true.

Q 12. *Statement 1:* For practical purposes, the earth is used as reference at zero potential in electrical circuits.

Statement 2: The electrical potential of a sphere of radius R with charge Q uniformly distributed on the surface is given by $\frac{Q}{4\pi\epsilon_0 R}$.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.

(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.

(C) Statement 1 is true, statement 2 is false.

(D) Statement 1 is false, statement 2 is true.

Q 13. *Statement 1:* It is easier to pull a heavy object than to push it on a level ground.

Statement 2: The magnitude of frictional force depends on the nature of the two surfaces in contact.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.

(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.

(C) Statement 1 is true, statement 2 is false.

(D) Statement 1 is false, statement 2 is true.

Paragraph Type

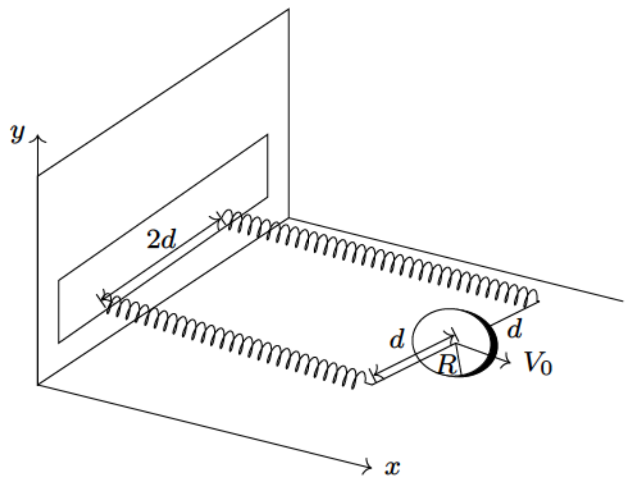
This section contains 6 questions based on two paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 14-16

A uniform thin cylindrical disc of mass M and radius R is attached to two identical massless springs of spring constant k which are fixed to the wall as shown in the figure. The springs are attached to the axle of the disc symmetrically on either side at a distance d from its centre. The axle is massless and both the springs and the axle are in horizontal plane. The unstretched length of each spring is L. The disc is initially at its equilibrium position with its centre of mass at a distance L from the wall. The disc rolls without slipping with velocity $\vec{V} = V_0\hat{\imath}$. The coefficient of friction is μ.

(2008)



Q 14. The net external force acting on the disc when its centre of mass is at displacement x with respect to its equilibrium position is
(A) $-kx$ (B) $-2kx$ (C) $-\frac{2}{3}kx$ (D) $-\frac{4}{3}kx$

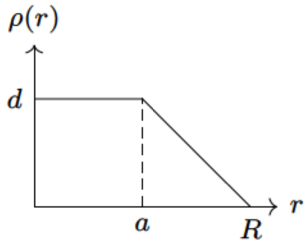
Q 15. The centre of mass of the disc undergoes SHM with angular frequency ω equal to
(A) $\sqrt{\frac{k}{M}}$ (B) $\sqrt{\frac{2k}{M}}$ (C) $\sqrt{\frac{2k}{3M}}$ (D) $\sqrt{\frac{4k}{3M}}$

Q 16. The maximum value of V_0 for which the disc will roll without slipping is

(A) $\mu g\sqrt{\frac{M}{k}}$ (B) $\mu g\sqrt{\frac{M}{2k}}$ (C) $\mu g\sqrt{\frac{3M}{k}}$ (D) $\mu g\sqrt{\frac{5M}{2k}}$

Paragraph for Questions 17-19

The nuclear charge (Ze) is non-uniformly distributed within a nucleus of radius R. The charge density $\rho(r)$ (charge per unit volume) is dependent only on the radial distance r from the centre of the nucleus as shown in the figure. The electric field is only along the radial direction. (2008)



Q 17. The electric field at $r = R$ is
(A) independent of a.
(B) directly proportional to a.
(C) directly proportional to a^2.
(D) inversely proportional to a.

Q 18. For $a = 0$, the value of d (maximum value of ρ as shown in the figure) is
(A) $\frac{3Ze}{4\pi R^3}$ (B) $\frac{3Ze}{\pi R^3}$ (C) $\frac{4Ze}{3\pi R^3}$ (D) $\frac{Ze}{3\pi R^3}$

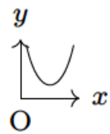
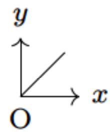
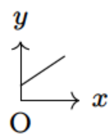
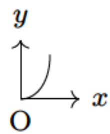
Q 19. The electric field within the nucleus is generally observed to be linearly dependent on r. This implies,
(A) $a = 0$ (B) $a = R/2$ (C) $a = R$ (D) $a = 2R/3$

Matrix or Matching Type

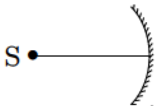
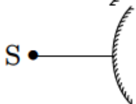
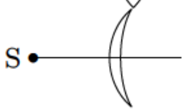
This section contains 3 questions. Each question contains two columns, column I and column II. Column I has four entries (A), (B), (C) and (D). Column II has five entries (p), (q), (r), and (s). Match the entries in column I with entries in column II. Any given statement in column I can have correct matching with one or more statement(s) given in column II. For each entry in column I, darken the bubbles of all the matching entries. For example, if entry (A) in column I matches with entries (q), (r) and (s), then darken these three bubbles. Similarly, for entries (B), (C) and (D). Marking scheme is:

1. Full Marks: (+6) If only the bubble corresponding to all the correct answer are darkened
2. Partial Marks: (+1) each for correct darkening of answers in any row
3. Zero Marks: (0) In all other cases

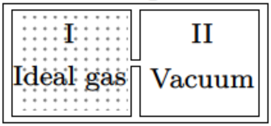
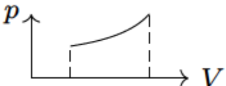
Q 20. *Column I* gives a list of possible set of parameters measured in some experiments. The variations of the parameters in the form of graphs are shown in *Column II*. Match the set of parameters given in *Column I* with the graphs given in *Column II*.

Column I	Column II
(A) Potential energy of a simple pendulum (y axis) as a function of displacement (x axis).	(p) 
(B) Displacement (y axis) as a function of time (x axis) for a one dimensional motion at zero or constant acceleration when the body is moving along the positive x direction.	(q) 
(C) Range of a projectile (y axis) as a function of its velocity (x axis) when projected at a fixed angle.	(r) 
(D) The square of time period (y axis) of a simple pendulum as a function of its length (x axis).	(s) 

Q 21. An optical component and an object S placed along its optic axis are given in *Column I*. The distance between the object and the component can be varied. The properties of the images are given in *Column II*. Match all the properties of images from *Column II* with the appropriate components given in *Column I*.

	Column I	Column II
(A)		(p) Real image
(B)		(q) Virtual image
(C)		(r) Magnified image
(D)		(s) Image at infinity

Q 22. *Column I* contains a list of processes involving expansion of an ideal gas. Match this with *Column II* describing the thermodynamic change during this process.

Column I	Column II
(A) An insulated container has two chambers separated by a valve. Chamber I contains an ideal gas and the chamber II has vacuum. The valve is opened. 	(p) Temperature of the gas decreases.
(B) An ideal monatomic gas expands to twice its original volume such that its pressure $p \propto \frac{1}{V^2}$, where V is the volume of the gas.	(q) Temperature of the gas increases or remains constant.
(C) An ideal monatomic gas expands to twice its original volume such that its pressure $p \propto \frac{1}{V^{4/3}}$, where V is its volume.	(r) The gas loses heat.
(D) An ideal monatomic gas expands such that its pressure p and volume V follows the behaviour shown in the figure. 	(s) The gas gains heat.

Answers

1. A
2. A
3. C
4. D
5. B
6. A
7. A
8. B
9. C
10. B
11. C
12. B
13. B
14. D
15. D
16. C
17. A
18. B
19. C
20. A$\mapsto$p, B$\mapsto$(q,r,s), C$\mapsto$s, D$\mapsto$q
21. A$\mapsto$(p,q,r,s), B$\mapsto$q, C$\mapsto$(p,q,r,s), D$\mapsto$(p,q,r,
22. A$\mapsto$q, B$\mapsto$(p,r), C$\mapsto$(p,s), D$\mapsto$(q,s)

IIT JEE 2007

IIT JEE 2007 was a single stage examination of two papers, Paper 1 and Paper 2, each of three hours duration. Each of the papers has three separate sections of physics, chemistry and mathematics. All questions were of objective type, designed to test comprehension, reasoning and analytical ability of the candidate.

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Paper 1

The physics part of the paper contains 22 questions. The questions are divided into four sections (1) single correct answer type (2) assertion reasoning type (3) paragraph type and (4) matrix-matching type.

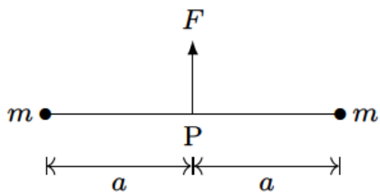
One Option Correct

This section contains 9 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 1. In an experiment to determine the focal length (f) of a concave mirror by the u-v method, a student places the object pin A on the principal axis at a distance x from the pole P. The student looks at the pin and its inverted image from a distance keeping his/her eye in line with PA. When the student shifts his/her eye towards left, the image appears to the right of the object pin. Then,
(A) $x < f$ (B) $f < x < 2f$ (C) $x = 2f$ (D) $x > 2f$

Q 2. Two particles of mass m each are tied at the ends of a light string of length $2a$. The whole system is kept on a frictionless horizontal surface with the string held tight so that each mass is at a distance a from the center P (see figure). Now, the mid-point of the string is pulled vertically upwards with a small but constant force F. As a result, the particles move towards each other on the surface. The magnitude of acceleration, when the separation between them becomes $2x$, is



(A) $\frac{F}{2m}\frac{a}{\sqrt{a^2-x^2}}$ (B) $\frac{F}{2m}\frac{x}{\sqrt{a^2-x^2}}$

(C) $\frac{F}{2m}\frac{x}{a}$ (D) $\frac{F}{2m}\frac{\sqrt{a^2-x^2}}{x}$

Q 3. A long, hollow conducting cylinder is kept coaxially inside another long, hollow conducting cylinder of larger radius. Both the cylinders are initially electrically neutral.

(A) A potential difference appears between the two cylinders when a charge density is given to the inner cylinder.

(B) A potential difference appears between the two cylinders when a charge density is given to the outer cylinder.

(C) No potential difference appears between the two cylinders when a uniform line charge is kept along the axis of the cylinders.

(D) No potential difference appears between the two cylinders when same charge density is given to both the cylinders.

Q 4. Consider a neutral conducting sphere. A positive point charge is placed outside the sphere. The net charge on the sphere is then,

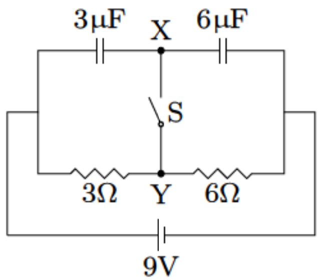
(A) negative and distributed uniformly over the surface of the sphere.

(B) negative and appears only at the point on the sphere closest to the point charge.

(C) negative and distributed non-uniformly over the entire surface of the sphere.

(D) zero.

Q 5. A circuit is connected as shown in the figure with the switch S open. When the switch is closed, the total amount of charge that flows from Y to X is



(A) 0 (B) 54 μC (C) 27 μC (D) 81 μC

Q 6. A ray of light traveling in water is incident on its surface open to air. The angle of incidence is θ, which is less than the critical angle. Then there will be

(A) only a reflected ray and no refracted ray.

(B) only a refracted ray and no reflected ray.

(C) a reflected ray and a refracted ray and the angle between them would be less than $180° - 2\theta$.

(D) a reflected ray and a refracted ray and the angle between them would be greater than $180° - 2\theta$.

Q 7. In the options given below, let E denotes the rest mass energy of a nucleus and n a neutron. The correct option is

(A) $E\left({}^{236}_{92}\mathrm{U}\right) > E\left({}^{137}_{53}\mathrm{I}\right) + E\left({}^{97}_{39}\mathrm{Y}\right) + 2E(n)$

(B) $E\left({}^{236}_{92}\mathrm{U}\right) < E\left({}^{137}_{53}\mathrm{I}\right) + E\left({}^{97}_{39}\mathrm{Y}\right) + 2E(n)$

(C) $E\left({}^{236}_{92}\mathrm{U}\right) < E\left({}^{140}_{56}\mathrm{Ba}\right) + E\left({}^{94}_{36}\mathrm{Kr}\right) + 2E(n)$

(D) $E\left({}^{236}_{92}\mathrm{U}\right) = E\left({}^{140}_{56}\mathrm{Ba}\right) + E\left({}^{94}_{36}\mathrm{Kr}\right) + 2E(n)$

Q 8. The largest wavelength in the ultraviolet region of the hydrogen spectrum is 122 nm. The smallest wavelength in the infrared region of the hydrogen spectrum (to the nearest integer) is
(A) 802 nm (B) 823 nm (C) 1882 nm (D) 1648 nm

Q 9. A resistance of $2\,\Omega$ is connected across one gap of a meter-bridge (the length of the wire is 100 cm) and an unknown resistance, greater than $2\,\Omega$, is connected across the other gap. When the resistances are interchanged, the balance point shifts by 20 cm. Neglecting any corrections, the unknown resistance is

(A) $3\,\Omega$ (B) $4\,\Omega$ (C) $5\,\Omega$ (D) $6\,\Omega$

Matrix or Matching Type

This section contains 3 matching type questions. Each question contains statements given in two columns. Statements in the first column have to be matched with statements in the second column. Marking scheme is:

1. Full Marks: (+6) If only the bubble corresponding to all the correct answer are darkened
2. Zero Marks: (0) In all other cases

Q 10. Some physical quantities are given in *Column I* and some possible SI units in which these quantities may be expressed are given in *Column II*. Match the physical quantities in *Column I* with the units in *Column II*.

Column I	Column II
(A) GM_eM_s, where G is universal gravitational constant, M_e mass of the earth and M_s mass of the Sun.	(p) volt coulomb metre
(B) $\frac{3RT}{M}$, where R is universal gas constant, T absolute temperature and M molar mass.	(q) kg m^3 s^{-2}
(C) $\frac{F^2}{q^2B^2}$, where F is force, q charge and B magnetic field.	(r) m^2 s^{-2}
(D) $\frac{GM_e}{R_e}$, where G is universal gravitational constant, M_e mass of the earth and R_e radius of the earth.	(s) farad volt^2 kg^{-1}

Q 11. *Column I* gives certain situations in which a straight metallic wire of resistance R is used and *Column II* gives some resulting effects. Match the statements in *Column I* with the statements in *Column II*.

Column I	Column II
(A) A charged capacitor is connected to the ends of the wire.	(p) A constant current flows through the wire.
(B) The wire is moved perpendicular to its length with a constant velocity in a uniform magnetic field perpendicular to the plane of motion.	(q) Thermal energy is generated in the wire.
(C) The wire is placed in a constant electric field that has a direction along the length of the wire.	(r) A constant potential difference develops between the ends of the wire.
(D) A battery of constant *emf* is connected to the ends of the wire.	(s) Charges of constant magnitude appear at the ends of the wire.

Q 12. Some laws/processes are given in *Column I*. Match these with the physical phenomena given in *Column II*.

Column I	Column II
(A) Transition between two atomic energy levels.	(p) Characteristic X-rays.
(B) Electron emission from a material.	(q) Photoelectric effect.
(C) Mosley's law.	(r) Hydrogen spectrum.
(D) Change of photon energy into kinetic energy of electrons.	(s) β-decay.

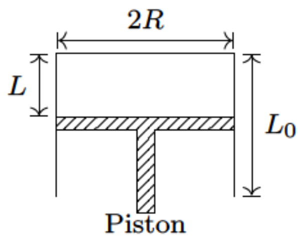
Paragraph Type

This section contains 6 questions based on two paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 13-15

A fixed thermally conducting cylinder has a radius R and height L_0. The cylinder is open at its bottom and has a small hole at its top. A piston of mass M is held at a distance L from the top surface as shown in the figure. The atmospheric pressure is p_0. (2007)



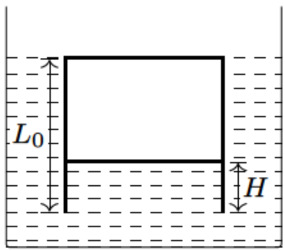
Q 13. The piston is now pulled out slowly and held at a distance $2L$ from the top. The pressure in the cylinder between its top and the piston will then be
(A) p_0 (B) $\frac{p_0}{2}$ (C) $\frac{p_0}{2} + \frac{Mg}{\pi R^2}$ (D) $\frac{p_0}{2} - \frac{Mg}{\pi R^2}$

Q 14. While the piston is at a distance $2L$ from the top, the hole at the top is sealed. The piston is then released, to a position where it can stay in equilibrium. In this condition, the distance of the piston from the top is

(A) $\left(\frac{2p_0\pi R^2}{\pi R^2 p_0+Mg}\right)2L$ (B) $\left(\frac{p_0\pi R^2-Mg}{\pi R^2 p_0}\right)2L$

(C) $\left(\frac{p_0\pi R^2+Mg}{\pi R^2 p_0}\right)2L$ (D) $\left(\frac{p_0\pi R^2}{\pi R^2 p_0-Mg}\right)2L$

Q 15. The piston is taken completely out of the cylinder. The hole at the top is sealed. A water tank is brought below the cylinder and put in a position so that the water surface in the tank is at the same level as the top of the cylinder as shown in the figure. The density of the water is ρ. In equilibrium, the height H of the water column in the cylinder satisfies



(A) $\rho g(L_0 - H)^2 + p_0(L_0 - H) + L_0 p_0 = 0$
(B) $\rho g(L_0 - H)^2 - p_0(L_0 - H) - L_0 p_0 = 0$
(C) $\rho g(L_0 - H)^2 + p_0(L_0 - H) - L_0 p_0 = 0$
(D) $\rho g(L_0 - H)^2 - p_0(L_0 - H) + L_0 p_0 = 0$

Paragraph for Questions 16-18

Two discs A and B are mounted coaxially on a vertical axle. The discs have moment of inertia I and $2I$ respectively about the common axis. Disc A is imparted an initial angular velocity 2ω using the entire potential energy of a spring compressed by a distance x_1. Disc B is imparted an angular velocity ω by a spring having the same spring constant and compressed by a distance x_2. Both the discs rotate in the clockwise direction. (2007)

Q 16. The ratio x_1/x_2 is
(A) 2 (B) $1/2$ (C) $\sqrt{2}$ (D) $1/\sqrt{2}$

Q 17. When disc B is brought in contact with disc A, they acquire a common angular velocity in time t. The average frictional torque on one disc by the other during this period is
(A) $\frac{2I\omega}{3t}$ (B) $\frac{9I\omega}{2t}$ (C) $\frac{9I\omega}{4t}$ (D) $\frac{3I\omega}{2t}$

Q 18. The loss of kinetic energy during the above process is
(A) $\frac{I\omega^2}{2}$ (B) $\frac{I\omega^2}{3}$ (C) $\frac{I\omega^2}{4}$ (D) $\frac{I\omega^2}{6}$

Assertion Reasoning Type

This section contains 4 reasoning type questions. Each question contains four options related to two statements, statement 1 and statement 2. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 19. *Statement 1:* A block of mass m starts moving on a rough horizontal surface with a velocity v. It stops due to friction between the block and the surface after moving through a certain distance. The surface is now tilted to an angle of $30°$ with the horizontal and the same block is made to go up on the surface with the same initial velocity v. The decrease in the mechanical energy in the second situation is smaller than that in the first situation.

Statement 2: The coefficient of friction between the block and the surface decreases with the increase in the angle of inclination.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.

(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.

(C) Statement 1 is true, statement 2 is false.

(D) Statement 1 is false, statement 2 is true.

Q 20. *Statement 1:* If the accelerating potential in an X-ray tube is increased, the wavelengths of the characteristic X-rays do not change.

Statement 2: When an electron beam strikes the target in an X-ray tube, part of the kinetic energy is converted into X-ray energy.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.

(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.

(C) Statement 1 is true, statement 2 is false.

(D) Statement 1 is false, statement 2 is true.

Q 21. *Statement 1:* The formula connecting u, v and f for a spherical mirror is valid only for mirrors whose sizes are very small compared to their radii of curvature.

Statement 2: Laws of reflection are strictly valid for plane surfaces, but not for large spherical surfaces.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.
(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.
(C) Statement 1 is true, statement 2 is false.
(D) Statement 1 is false, statement 2 is true.

Q 22. *Statement 1:* In an elastic collision between two bodies, the relative speed of the bodies after collision is equal to the relative speed before the collision.

Statement 2: In an elastic collision, the linear momentum of the system is conserved.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.

(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.

(C) Statement 1 is true, statement 2 is false.

(D) Statement 1 is false, statement 2 is true.

Answers

1. B
2. B
3. A
4. D
5. C
6. C
7. A
8. B
9. A
10. A$\mapsto$(p,q), B$\mapsto$(r,s), C$\mapsto$(r,s), D$\mapsto$(r,s)
11. A$\mapsto$q, B$\mapsto$(r, s), C$\mapsto$(r, s), D$\mapsto$(p, q, r)
12. A$\mapsto$(p,r), B$\mapsto$(q,s), C$\mapsto$p, D$\mapsto$q
13. A
14. D
15. C
16. C
17. A
18. B
19. C
20. B
21. C
22. B

Paper 2

The physics part of the paper contains 22 questions. The questions are divided into four sections (1) single correct answer type (2) assertion reasoning type (3) paragraph type and (4) matrix-matching type.

One Option Correct

This section contains 9 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: −1 In all other cases

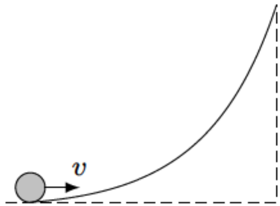
Q 1. A student performs an experiment to determine the Young's modulus of a wire, exactly 2 m long, by Searle's method. In a particular reading, the student measures the extension in the length of the wire to be 0.8 mm with an uncertainty of ± 0.05 mm at a load of exactly 1.0 kg. The student also measures the diameter of the wire to be 0.4 mm with an uncertainty of ± 0.01 mm. Take $g = 9.8\ \mathrm{m/s^2}$ (exact). The Young's modulus obtained from the reading is

(A) $(2.0 \pm 0.3) \times 10^{11}\ \mathrm{N/m^2}$
(B) $(2.0 \pm 0.2) \times 10^{11}\ \mathrm{N/m^2}$
(C) $(2.0 \pm 0.1) \times 10^{11}\ \mathrm{N/m^2}$
(D) $(2.0 \pm 0.05) \times 10^{11}\ \mathrm{N/m^2}$

Q 2. A particle moves in the x-y plane under the influence of a force such that its linear momentum is $\vec{p}(t) = A\,(\hat{\imath}\cos kt - \hat{\jmath}\sin kt)$, where A and k are constants. The angle between the force and the momentum is

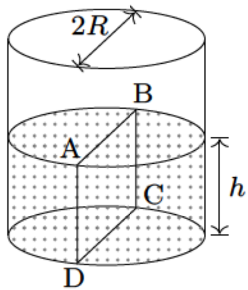
(A) $0°$ (B) $30°$ (C) $45°$ (D) $90°$

Q 3. A small object of uniform density rolls up a curved surface with an initial velocity v. It reaches up to a maximum height of $\frac{3v^2}{4g}$ with respect to the initial position. The object is



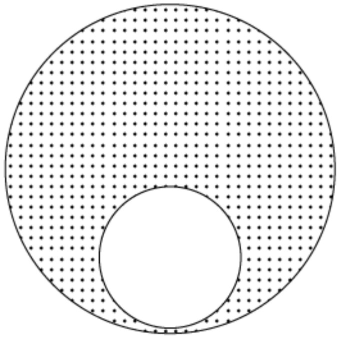
(A) ring (B) solid sphere
(C) hollow sphere (D) disc

Q 4. Water is filled up to a height h in a beaker of radius R as shown in the figure. The density of water is ρ, the surface tension of water is T and the atmospheric pressure is P_0. Consider a vertical section ABCD of the water column through a diameter of the beaker. The force on water on one side of this section by water on the other side of this section has magnitude



(A) $|2P_0Rh + \pi R^2\rho gh - 2RT|$
(B) $|2P_0Rh + R\rho gh^2 - 2RT|$
(C) $|P_0\pi R^2 + R\rho gh^2 - 2RT|$
(D) $|P_0\pi R^2 + R\rho gh^2 + 2RT|$

Q 5. A spherical portion has been removed from a solid sphere having a charge distribution uniformly in its volume as shown in the figure. The electric field inside the emptied space is

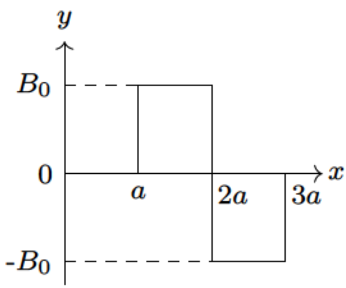


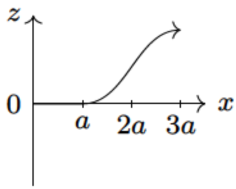
(A) zero everywhere (B) non-zero and uniform
(C) non-uniform (D) zero only at its center

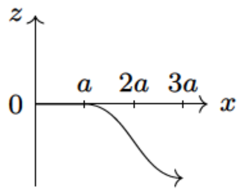
Q 6. Positive and negative point charges of equal magnitude are kept at $\left(0, 0, \frac{a}{2}\right)$ and $\left(0, 0, -\frac{a}{2}\right)$, respectively. The work done by the electric field when another positive point charge is moved from $(-a, 0, 0)$ to $(0, a, 0)$ is

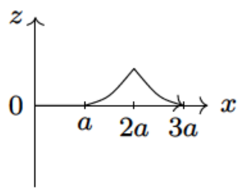
(A) positive
(B) negative
(C) zero
(D) depends on the path connecting the initial and final positions.

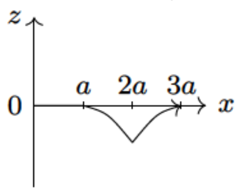
Q 7. A magnetic field vector $\vec{B} = B_0\hat{\jmath}$ exists in the region $a < x < 2a$ and vector $\vec{B} = -B_0\hat{\jmath}$, in the region $2a < x < 3a$, where B_0 is a positive constant. A positive point charge moving with a velocity vector $\vec{v} = v_0\hat{\imath}$, where v_0 is a positive constant, enters the magnetic field at $x = a$. The trajectory of the charge in this region can be like



(A) 

(B) 

(C) 

(D) 

Q 8. Electrons with de-Broglie wavelength λ fall on the target in an X-ray tube. The cut-off wavelength of the emitted X-rays is

(A) $\frac{2mc\lambda^2}{h}$ (B) $\frac{2h}{mc}$ (C) $\frac{2m^2c^2\lambda^3}{h^2}$ (D) λ

Q 9. In the experiment to determine the speed of sound using a resonance column,

(A) prongs of the tuning fork are kept in a vertical plane.

(B) prongs of the tuning fork are kept in a horizontal plane.

(C) in one of the two resonances observed, the length of the resonating air column is close to the wavelength of sound in air.

(D) in one of the two resonances observed, the length of the resonating air column is close to half of the wavelength of sound in air.

Assertion Reasoning Type

This section contains 4 reasoning type questions. Each question contains four options related to two statements, statement 1 and statement 2. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 10. *Statement 1:* If there is no external torque on a body about its centre of mass, then the velocity of the centre of mass remains constant.

Statement 2: The linear momentum of an isolated system remains constant.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.
(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.
(C) Statement 1 is true, statement 2 is false.
(D) Statement 1 is false, statement 2 is true.

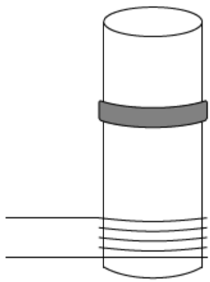
Q 11. *Statement 1:* The total translational kinetic energy of all the molecules of a given mass of an ideal gas is 1.5 times the product of its pressure and its volume.

Statement 2: The molecules of a gas collide with each other and the velocities of the molecules change due to the collision.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.
(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.
(C) Statement 1 is true, statement 2 is false.
(D) Statement 1 is false, statement 2 is true.

Q 12. *Statement 1:* A vertical iron rod has a coil of wire wound over it at the bottom end. An alternating current flows in the coil. The rod goes through a conducting ring as shown in the figure. The ring can float at a certain height above the coil.

Statement 2: In the above situation, a current is induced in the ring which interacts with the horizontal component of the magnetic field to produce an average force in the upward direction.



(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.
(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.
(C) Statement 1 is true, statement 2 is false.
(D) Statement 1 is false, statement 2 is true.

Q 13. *Statement 1:* A cloth covers a table. Some dishes are kept on it. The cloth can be pulled out without dislodging the dishes from the table.

Statement 2: For every action there is an equal and opposite reaction.

(A) Statement 1 is true, statement 2 is true; statement 2 is a correct explanation for statement 1.

(B) Statement 1 is true, statement 2 is true; statement 2 is *not* a correct explanation for statement 1.

(C) Statement 1 is true, statement 2 is false.

(D) Statement 1 is false, statement 2 is true.

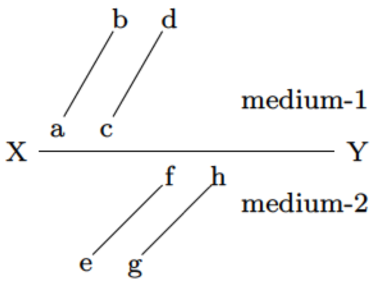
Paragraph Type

This section contains 6 questions based on two paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+4) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Paragraph for Questions 14-16

The figure shows a surface XY separating two transparent media, medium-1 and medium-2. The lines ab and cd represent wavefronts of a light wave travelling in medium-1 and incident on XY. The lines ef and gh represents wavefronts of the light wave in medium-2 after refraction. (2007)



Q 14. Light travels as a

(A) parallel beam in each medium.
(B) convergent beam in each medium.
(C) divergent beam in each medium.
(D) divergent beam in one medium and convergent beam in other medium.

Q 15. The phases of the light wave at c, d, e and f are ϕ_c, ϕ_d, ϕ_e and ϕ_f respectively. It is given that $\phi_c \neq \phi_f$.
(A) ϕ_c cannot be equal to ϕ_d.
(B) ϕ_d can be equal to ϕ_e.
(C) $(\phi_d - \phi_f)$ is equal to $(\phi_c - \phi_e)$.
(D) $(\phi_d - \phi_c)$ is not equal to $(\phi_f - \phi_e)$.

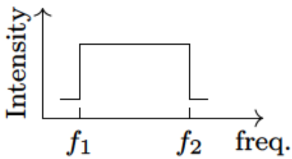
Q 16. Speed of light is

(A) the same in medium-1 and medium-2.
(B) larger in medium-1 than in medium-2.
(C) larger in medium-2 than in medium-1.
(D) different at b and d.

Paragraph for Questions 17-19

Two trains A and B are moving with speed 20 m/s and 30 m/s respectively in the same direction on the same straight track, with B ahead of A. The engines are at the front ends. The engine of train A blows a whistle. Assume that the sound of the whistle is composed of components varying in frequency from $f_1 = 800$ Hz to $f_2 = 1120$ Hz, as shown in the figure. The spread in the frequency (highest frequency – lowest frequency) is thus 320 Hz. The speed of sound in air is 340 m/s.

(2007)



Q 17. The speed of sound of the whistle is

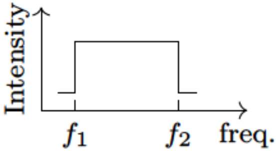
(A) 340 m/s for passengers in A and 310 m/s for passengers in B.

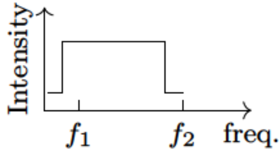
(B) 360 m/s for passengers in A and 310 m/s for passengers in B.

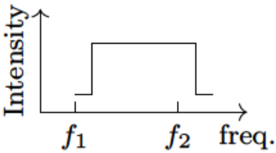
(C) 310 m/s for passengers in A and 360 m/s for passengers in B.

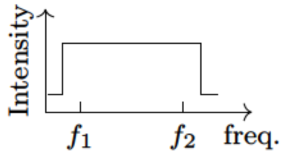
(D) 340 m/s for passengers in both the trains.

Q 18. The distribution of the sound intensity of the whistle as observed by the passengers in train A is best represented by

(A) 

(B) 

(C) 

(D) 

Q 19. The spread of frequency as observed by the passengers in train B is
(A) 310 Hz (B) 330 Hz (C) 350 Hz (D) 290 Hz

Matrix or Matching Type

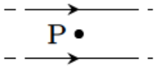
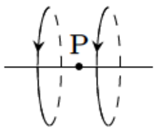
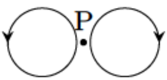
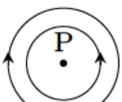
This section contains 3 matching type questions. Each question contains statements given in two columns. Statements in the first column have to be matched with statements in the second column. Marking scheme is:

1. Full Marks: (+6) If only the bubble corresponding to all the correct answer are darkened
2. Zero Marks: (0) In all other cases

Q 20. *Column I* describes some situations in which a small object moves. *Column II* describes some characteristics of these motions. Match the situations in *Column I* with the characteristics in *Column II.*

Column I	Column II
(A) The object moves on the x-axis under a conservative force in such a way that its speed and position satisfy $v = c_1\sqrt{c_2 - x^2}$, where c_1 and c_2 are positive constants.	(p) The object executes a SHM.
(B) The object moves on the x-axis in such a way that its velocity and its displacement from the origin satisfy $v = -kx$, where k is a positive constant.	(q) The object does not change its direction.
(C) The object is attached to one end of a massless spring of a given spring constant. The other end of the spring is attached to the ceiling of an elevator. Initially everything is at rest. The elevator starts going upwards with a constant acceleration a. The motion of the object is observed from the elevator during the period it maintains this acceleration.	(r) The kinetic energy of the object keeps on decreasing.

Q 21. Two wires each carrying a steady current i are shown in four configurations in *Column I*. Some of the resulting effects are described in *Column II*. Match the statements in *Column I* with the statements in *Column II*.

Column I	Column II
(A) Point P is situated midway between the wires. 	(p) The magnetic field at P due to the currents in the wires are in the same direction.
(B) Point P is situated at the mid-point of the line joining the centers of the circular wires, which have same radii. 	(q) The magnetic field at P due to the currents in the wires are in the opposite directions.
(C) Point P is situated at the mid-point of the line joining the centers of the circular wires, which have same radii. 	(r) There is no magnetic field at P.
(D) Point P is situated at the common center of the wires. 	(s) The wires repel each other.

Q 22. *Column I* gives some devices and *Column II* gives some processes on which the functioning of these devices depend. Match the devices in *Column I* with the processes in *Column II*.

Column I	Column II
(A) Bimetallic strip	(p) Radiation from a hot body
(B) Steam engine	(q) Energy conversion
(C) Incandescent lamp	(r) Melting
(D) Electric fuse	(s) Thermal expansion of solids

Answers

1. B
2. D
3. D
4. B
5. B
6. C
7. A
8. A
9. A
10. D
11. B
12. A
13. B
14. A
15. C
16. B
17. B
18. A
19. A
20. A$\mapsto$p, B$\mapsto$(q, r), C$\mapsto$p, D$\mapsto$(q, r)
21. A$\mapsto$(q,r), B$\mapsto$p, C$\mapsto$(q,r), D$\mapsto$q
22. A$\mapsto$s, B$\mapsto$q, C$\mapsto$p, D$\mapsto$r

IIT JEE 2006

The format of IIT JEE 2006 was different. Unlike earlier years, IIT JEE 2006 did not have two-stages (screening and mains), but only one stage. There were three different papers for physics, chemistry and mathematics, each of 2 hour duration with 40 questions.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper

The physics paper contains 40 questions of total marks 184. The questions are divided into five sections (1) single answer correct type (2) multiple correct answers type (3) matrix-matching type (4) paragraph type and (5) descriptive type.

One Option Correct

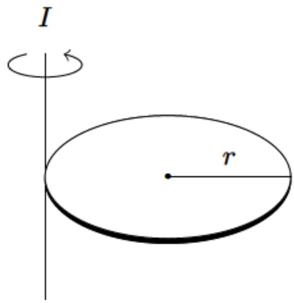
This section contains 12 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+3) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: -1 In all other cases

Q 1. A student performs an experiment for determination of $g\left(=\frac{4\pi^2 l}{T^2}\right)$. The error in pendulum length $l\,(\approx 1\text{ m})$ is Δl. To measure time period T, the student takes total time of n oscillations with a stop watch of least count ΔT_{lc} and (s)he commits a human error of $\Delta T_{\text{h}} = 0.1\text{ s}$. The amplitude of oscillation is A. The measurement of g is most accurate for

(A) $\Delta l = 5\text{ mm}, \Delta T_{\text{lc}} = 0.2\text{ s}, n = 10, A = 5\text{ mm}$
(B) $\Delta l = 5\text{ mm}, \Delta T_{\text{lc}} = 0.2\text{ s}, n = 20, A = 5\text{ mm}$
(C) $\Delta l = 5\text{ mm}, \Delta T_{\text{lc}} = 0.1\text{ s}, n = 20, A = 1\text{ mm}$
(D) $\Delta l = 1\text{ mm}, \Delta T_{\text{lc}} = 0.1\text{ s}, n = 50, A = 1\text{ mm}$

Q 2. A solid sphere of radius R has moment of inertia I about its geometrical axis. It is melted into a disc of radius r and thickness t. If its moment of inertia about the tangential axis (which is perpendicular to plane of the disc), is also equal to I, then the value of r is equal to



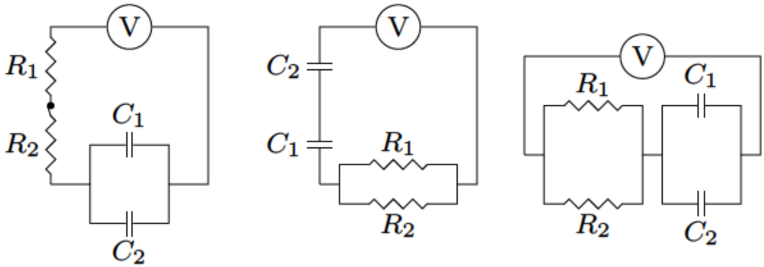
(A) $\frac{2}{\sqrt{15}}R$ (B) $\frac{2}{\sqrt{5}}R$ (C) $\frac{3}{\sqrt{15}}R$ (D) $\frac{\sqrt{2}}{\sqrt{15}}R$

Q 3. A double star system consists of two stars A and B which have time periods T_A and T_B, radius R_A and R_B and mass M_A and M_B. Choose the correct option.

(A) If $T_A > T_B$ then $R_A > R_B$
(B) If $T_A > T_B$ then $M_A > M_B$
(C) $T_A/T_B = (R_A/R_B)^{3/2}$
(D) $T_A = T_B$

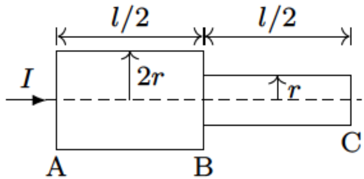
Q 4. Half-life of a radioactive substance A is 4 days. The probability that a nucleus will decay in two half-lives is
(A) 1/4 (B) 3/4 (C) 1/2 (D) 1

Q 5. Find the time constant for the given R-C circuits in correct order (in μs), [Given $R_1 = 1\,\Omega$, $R_2 = 2\,\Omega$, $C_1 = 4\,\mu F$, $C_2 = 2\,\mu F$.]



(A) $18, 4, 8/9$ (B) $18, 8/9, 4$
(C) $4, 18, 8/9$ (D) $4, 8/9, 18$

Q 6. Two bars of radius r and $2r$ are kept in contact as shown. An electric current I is passed through the bars. Which one of following is correct?



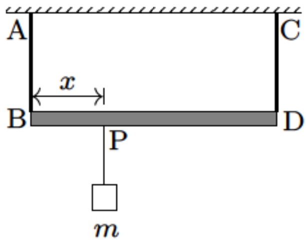
(A) Heat produced in bar BC is 4 times the heat produced in bar AB.

(B) Electric field in both halves is equal.

(C) Current density across AB is double that across BC.

(D) Potential difference across AB is 4 times that of across BC.

Q 7. A massless rod BD is suspended by two identical massless strings AB and CD of equal length. A block of mass m is suspended from point P such that BP is equal to x. If the fundamental frequency of the left wire is twice the fundamental frequency of right wire, then the value of x is



(A) $l/5$ (B) $l/4$ (C) $4l/5$ (D) $3l/4$

Q 8. A biconvex lens of focal length f forms a circular image of radius r of sun in focal plane. Then which option is correct?

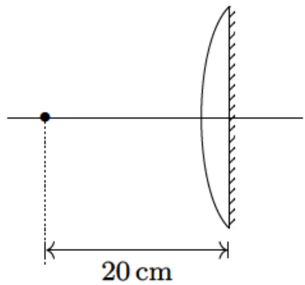
(A) $\pi r^2 \propto f$

(B) $\pi r^2 \propto f^2$

(C) If lower half part is covered by black sheet, then area of the image is equal to $\pi r^2/2$.

(D) If f is doubled, intensity will increase.

Q 9. A point object is placed at a distance of 20 cm from a thin plano-convex lens of focal length 15 cm. The plane surface of the lens is now silvered. The image created by the system is at



(A) 60 cm to the left of the system
(B) 60 cm to the right of the system
(C) 12 cm to the left of the system
(D) 12 cm to the right of the system

Q 10. In a screw gauge, the zero of main scale coincides with fifth division of circular scale as shown in the figure (i). The circular scale of a screw gauge has 50 divisions and its pitch is 0.5 mm. The diameter of the ball being measured in the figure (ii) is

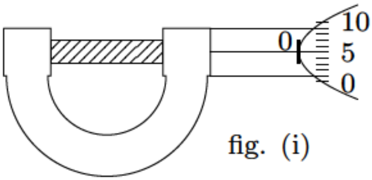


fig. (i)

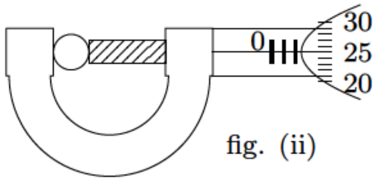
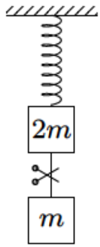


fig. (ii)

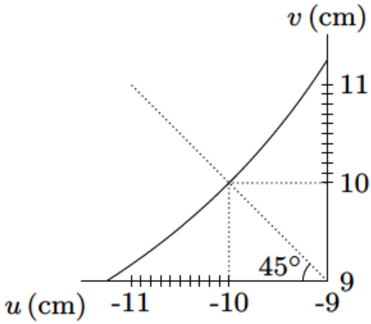
(A) 1.2 mm (B) 1.25 mm (C) 2.20 mm (D) 2.25 mm

Q 11. System shown in the figure is in equilibrium and at rest. The string is massless and inextensible and spring is massless. The acceleration of the mass $2m$ and m just after the string is cut will be



(A) $g/2$ upwards, g downwards
(B) g upwards, $g/2$ downwards
(C) g upwards, $2g$ downwards
(D) $2g$ upwards, g downwards

Q 12. The graph between object distance u and the image distance v for a lens is as shown. The focal length of the lens is



(A) 5 ± 0.1 (B) 5 ± 0.05
(C) 0.5 ± 0.1 (D) 0.5 ± 0.05

One or More Option(s) Correct

This section contains 8 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four options is(are) correct. Marking scheme is:

1. Full Marks: (+5) If only the bubble(s) corresponding to all the correct option(s) is(are) darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−1) In all other cases

Q 13. A solid sphere is in pure rolling motion on an inclined surface having inclination θ,

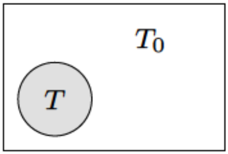
(A) frictional force acting on sphere is $f = \mu mg \cos\theta$.

(B) f is dissipative force.

(C) friction will increase its angular velocity and decrease its linear velocity.

(D) if θ decreases, frictional force will decrease.

Q 14. In a dark room with ambient temperature T_0, a black body is kept at temperature T. Keeping the temperature of the black body constant (at T), sun rays are allowed to fall on the black body through a hole in the roof of the dark room. Assuming that there is no change in the ambient temperature of the room, which of the following statement(s) is (are) correct?



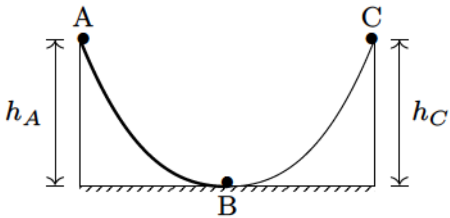
(A) The quantity of radiation absorbed by the black body in unit time will increase.

(B) Since emissivity = absorptivity, hence the quantity of radiation emitted by black body in unit time will increase.

(C) Black body radiates more energy in unit time in the visible spectrum.

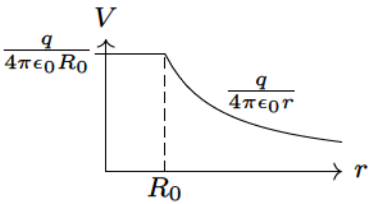
(D) The reflected energy in unit time by the black body remains same.

Q 15. A ball moves over a fixed track as shown in the figure. From A to B the ball rolls without slipping. If surface BC is frictionless and K_A, K_B and K_C are kinetic energies of the ball at A, B and C respectively, then,



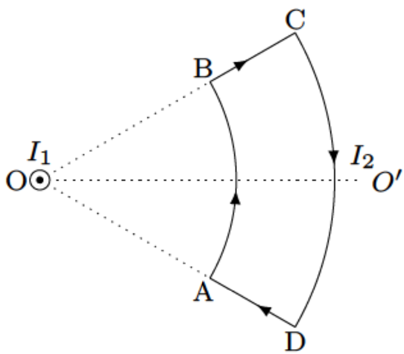
(A) $h_A > h_C$, $K_B > K_C$ (B) $h_A > h_C$, $K_C > K_A$
(C) $h_A = h_C$, $K_B = K_C$ (D) $h_A < h_C$, $K_B > K_C$

Q 16. For spherical symmetrical charge distribution, variation of electric potential, V, with distance from centre, r, is given in the figure. Which of the following option(s) is (are) correct?



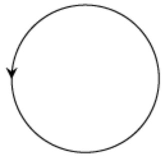
(A) Total charge within $2R_0$ is q.
(B) Total electrostatic energy for $r \leq R_0$ is zero.
(C) At $r = R_0$ electric field is discontinuous.
(D) There will be no charge anywhere except at $r = R_0$.

Q 17. An infinitely long wire carrying current I_1 passes through O and is perpendicular to the plane of paper. Another current carrying loop ABCD lies in plane of paper as shown in the figure. Which of the following statement(s) is (are) correct?



(A) net force on the loop is zero.
(B) net torque on the loop is zero.
(C) loop will rotate clockwise about axis OO′ when seen from O.
(D) loop will rotate anticlockwise OO′ when seen from O.

Q 18. A field line is shown in the figure. This field cannot represent,

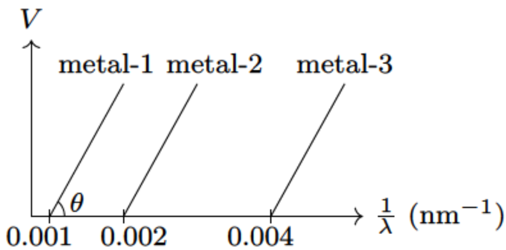


(A) Magnetic field (B) Electrostatic field
(C) Induced electric field (D) Gravitational field

Q 19. Function $x = A\sin^2\omega t + B\cos^2\omega t + C\sin\omega t\cos\omega t$ represents SHM,

(A) For any value of A, B and C (except $C = 0$)
(B) If $A = -B$, $C = 2B$, amplitude $= |B\sqrt{2}|$
(C) If $A = B$, $C = 0$
(D) If $A = B$, $C = 2B$, amplitude $= |B|$

Q 20. The graph between $1/\lambda$ and stopping potential (V) of three metals having work functions ϕ_1, ϕ_2 and ϕ_3 in an experiment of photoelectric effect is plotted as shown in the figure. Which of the following statement(s) is (are) correct? (Here λ is the wavelength of the incident ray.)



(A) $\phi_1 : \phi_2 : \phi_3 = 1 : 2 : 4$.
(B) $\phi_1 : \phi_2 : \phi_3 = 4 : 2 : 1$.
(C) $\tan\theta$ is directly proportional to hc/e, where h is Planck's constant and c is the speed of light.
(D) The violet colour light can eject photoelectrons from metal 2 and 3.

Matrix or Matching Type

This section contains 4 matching type questions. Each question contains statements given in two columns. Statements in the first column have to be matched with statements in the second column. Marking scheme is:

1. Full Marks: (+6) If only the bubble corresponding to all the correct answer are darkened
2. Zero Marks: (0) In all other cases

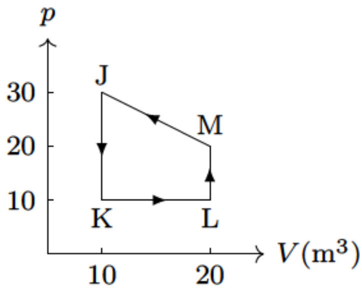
Q 21. Some laws/processes are given in *Column I*. Match these with the physical phenomena given in *Column II*.

Column I	Column II
(A) Dielectric ring uniformly charged.	(p) Time independent electrostatic field out of system.
(B) Dielectric ring uniformly charged rotating with angular velocity ω.	(q) Magnetic field.
(C) Constant current in ring i_0.	(r) Induced electric field.
(D) $i = i_0 \cos \omega t$.	(s) Magnetic moment.

Q 22. *Column I* gives some properties of a simple telescope used to view distant objects having eyepiece and objective lens of focal lengths f_e and f_o. Match these properties with parameters given in *Column II.*

Column I	Column II
(A) Intensity of light received by lens	(p) radius of aperture (R)
(B) Angular magnification	(q) dispersion of lens
(C) Length of telescope	(r) focal length f_o, f_e
(D) Sharpness of image	(s) spherical aberration

Q 23. Match the following for the given process,



Column I	Column II
(A) Process $J \to K$	(p) $W > 0$
(B) Process $K \to L$	(q) $Q < 0$
(C) Process $L \to M$	(r) $W < 0$
(D) Process $M \to J$	(s) $Q > 0$

Q 24. Some laws/processes are given in *Coulumn I*. Match these with the physical phenomenon given in *Column II*.

Column I	Column II
(A) Nuclear fusion	(p) Converts some matter into energy.
(B) Nuclear fission	(q) Generally possible for nuclei with low atomic number.
(C) β-decay	(r) Generally possible for nuclei with higher atomic number.
(D) Exothermic nuclear reaction	(s) Essentially proceeds by weak nuclear forces.

Paragraph Type

This section contains 12 questions based on 4 paragraphs. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Marking scheme is:

1. Full Marks: (+5) If only the bubble corresponding to the correct answer is darkened
2. Zero Marks: (0) If none of the bubbles is darkened
3. Negative Marks: (−2) In all other cases

Paragraph for Questions 25-27

Two plane harmonic sound waves are expressed by the equations: $y_1 = A\cos(0.5\pi x - 100\pi t)$ and $y_2 = A\cos(0.46\pi x - 92\pi t)$. [All parameters are in MKS units.] **(2006)**

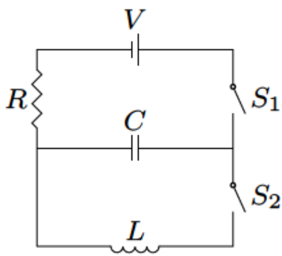
Q 25. How many times does an observer hear maximum intensity in one second?
(A) 4 (B) 10 (C) 6 (D) 8

Q 26. What is the speed of the sound?
(A) 200 m/s (B) 180 m/s (C) 192 m/s (D) 96 m/s

Q 27. At $x = 0$ how many times the amplitude of $y_1 + y_2$ is zero in one second?
(A) 192 (B) 48 (C) 100 (D) 96

Paragraph for Questions 28-30

The capacitor of capacitance C can be charged (with the help of a resistance R) by a voltage source V, by closing switch S_1 while keeping switch S_2 open. The capacitor can be connected with an inductor L by closing switch S_2 and opening S_1. (2006)



Q 28. Initially, the capacitor was uncharged. Now, switch S_1 is closed and S_2 is kept open. If time constant of this circuit is τ, then,

(A) after time interval τ, charge on capacitor is $CV/2$.

(B) after time interval 2τ, charge on capacitor is $CV\left(1 - e^{-2}\right)$.

(C) the work done by the voltage source will be half of the heat dissipated when the capacitor is fully charged.

(D) after time interval 2τ, charge on capacitor is $CV\left(1 - e^{-1}\right)$.

Q 29. After the capacitor gets fully charged, S_1 is opened and S_2 is closed so that the inductor is connected in series with the capacitor. Then,

(A) at $t = 0$, energy stored in the circuit is purely in the form of magnetic energy.

(B) at any time $t > 0$, current in the circuit is in the same direction.

(C) at $t > 0$, there is no exchange of energy between the inductor and capacitor.

(D) at any time $t > 0$, maximum instantaneous current in the circuit may be $V\sqrt{C/L}$.

Q 30. If the total charge stored in the LC circuit is q_0, then for $t \geq 0$,

(A) the charge on the capacitor is $q = q_0 \cos\left(\frac{\pi}{2} + \frac{t}{\sqrt{LC}}\right)$.

(B) the charge on the capacitor is $q = q_0 \cos\left(\frac{\pi}{2} - \frac{t}{\sqrt{LC}}\right)$.

(C) the charge on the capacitor is $q = -LC\frac{\mathrm{d}^2 q}{\mathrm{d}t^2}$.

(D) the charge on the capacitor is $q = -\frac{1}{\sqrt{LC}}\frac{\mathrm{d}^2 q}{\mathrm{d}t^2}$.

Paragraph for Questions 31-33

Modern trains are based on Maglev technology in which trains are magnetically levitated. There are coils on both sides of wheels. Due to motion of train, current induces in the coil of track which levitate it. This is in accordance with Lenz's law. If trains lower down then due to Lenz's law a repulsive force increases due to which train gets uplifted and if it goes much high then there is a net downward force due to gravity. The advantage of Maglev train is that there is no friction between the train and the track, thereby reducing power consumption and enabling the train to attain very high speeds. Disadvantage of Maglev train is that as it slows down the electromagnetic force decreases and it becomes difficult to keep it leviated and as it moves forward, according to Lenz's law, there is an electromagnetic drag force. (2006)

Q 31. What is the advantage of this system?

(A) No friction hence no power consumption.
(B) No electric power is used.
(C) Gravitation force is zero.
(D) Electrostatic force draws the train.

Q 32. What is the disadvantage of this system?

(A) Train experiences upward force according to Lenz's law.

(B) Friction force creates a drag on the train.

(C) Retardation.

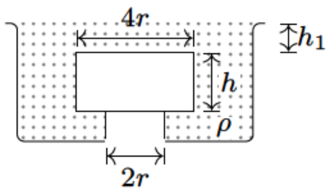
(D) By Lenz's law train experiences a drag.

Q 33. Which force causes the train to elevate up?
(A) Electrostatic force.
(B) Time varying electric field.
(C) Magnetic force.
(D) Induced electric field.

Paragraph for Questions 34-36

A wooden cylinder of diameter $4r$, height h and density $\rho/3$ is kept on a hole of diameter $2r$ of a tank, filled with liquid of density ρ as shown in the figure.

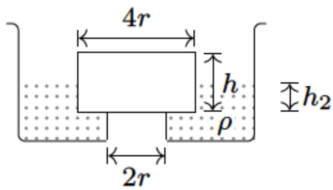
(2006)



Q 34. Now, level of the liquid starts decreasing slowly. When the level of liquid is at a height h_1 above the cylinder, the block just starts moving up. Then value of h_1 is

(A) $2h/3$ (B) $5h/4$ (C) $5h/3$ (D) $5h/2$

Q 35. Let the cylinder is prevented from moving up, by applying a force and water level is further decreased. Then, height of water level (h_2 in figure) for which the cylinder remains in original position without application of force is



(A) $4h/9$ (B) $5h/9$ (C) h (D) $2h/3$

Q 36. If height h_2 of water level is further decreased, then,

(A) cylinder will not move up and remains at its original position.

(B) for $h_2 = h/3$, cylinder again starts moving up.

(C) for $h_2 = h/4$, cylinder again starts moving up.

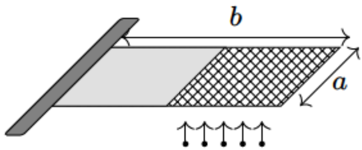
(D) for $h_2 = h/5$, cylinder again starts moving up.

Descriptive

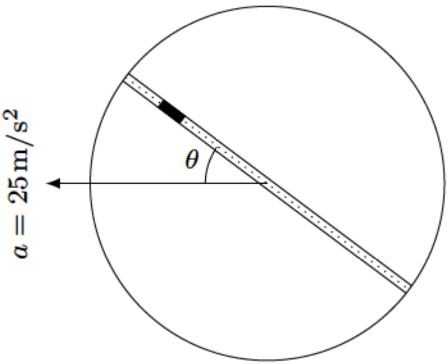
This section contains 4 descriptive questions. Each question is of 6 marks.

Q 37. In an insulated vessel, 0.05 kg steam at 373 K and 0.45 kg of ice at 253 K are mixed. Find the final temperature of the mixture (in Kelvin). [Given, $L_{\text{fusion}} = 80\ \text{cal/g} = 336\ \text{J/g}$, $L_{\text{vaporization}} = 540\ \text{cal/g} = 2268\ \text{J/g}$, $S_{\text{ice}} = 2100\ \text{J/kg K} = 0.5\ \text{cal/(g K)}$, $S_{\text{water}} = 4200\ \text{J/kg K} = 1\ \text{cal/(g K)}$.]

Q 38. There is a rectangular plate of mass M kg of dimensions $(a \times b)$. The plate is held in horizontal position by striking n small balls uniformly each of mass m per unit area per unit time. These are striking in the shaded half region of the plate. The balls are colliding elastically with velocity v. What is v? [Given $n = 100$, $M = 3$ kg, $m = 0.01$ kg, $b = 2$ m, $a = 1$ m, $g = 10$ m/s^2.]



Q 39. A circular disc with a groove along its diameter is placed horizontally. A block of mass 1 kg is placed as shown in the figure. The coefficient of friction between the block and all surfaces of groove in contact is $\mu = 2/5$. The disc has an acceleration of $25\ \mathrm{m/s^2}$. Find the acceleration of the block with respect to disc.



$\cos\theta = 4/5,\ \sin\theta = 3/5$

Q 40. In hydrogen-like atom ($Z = 11$), n^{th} line of Lyman series has wavelength equal to the de-Broglie's wavelength of electron in the level from which it originated. What is the value of n?

Answers

1. (D)
2. A
3. D
4. B
5. B
6. A
7. A
8. B
9. C
10. A
11. A
12. B
13. C, D
14. A, B
15. A, B, D
16. A, B, C, D
17. A, C
18. B, D
19. A, B, D
20. A, C
21. A$\mapsto$p, B$\mapsto$(q, s), C$\mapsto$(q, s), D$\mapsto$(q, r, s)
22. A$\mapsto$p, B$\mapsto$r, C$\mapsto$r, D$\mapsto$(p,q,s)
23. A$\mapsto$q, B$\mapsto$(p,s), C$\mapsto$s, D$\mapsto$(q,r)
24. A$\mapsto$(p,q), B$\mapsto$(p,r), C$\mapsto$(p,s), D$\mapsto$(p,q,r)
25. A
26. A
27. C
28. B
29. D
30. C
31. A
32. D
33. C
34. C
35. A
36. A
37. 273 K
38. 10 m/s
39. 10 m/s^2
40. 24

IIT JEE 2005

IIT JEE 2005 has a screening paper and a main paper.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Screening Paper

The physics part of screening paper has 28 objective questions of the single option correct type.

One Option Correct

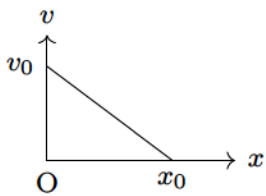
Each question has four options (A), (B), (C) and (D). Only one of these four options is correct.

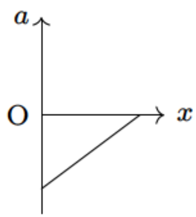
Q 1. A moving coil galvanometer of resistance 100 Ω is used as an ammeter using a resistance 0.1 Ω. The maximum deflection current in the galvanometer is 100 μA. Find the current in the circuit, so that the ammeter shows maximum deflection.

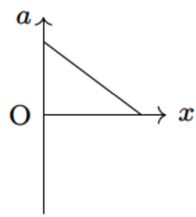
(A) 100.1 mA (B) 1000.1 mA
(C) 10.01 mA (D) 1.01 mA

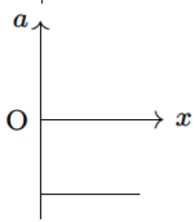
Q 2. Which of the following sets have different dimensions,
(A) Pressure, Young's modulus, Stress
(B) EMF, Potential difference, Electric potential
(C) Heat, Work done, Energy
(D) Dipole moment, Electric flux, Electric field

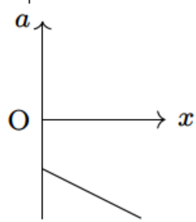
Q 3. The given graph shows the variation of velocity (v) with displacement (x). Which one of the following graph correctly represents the variation of acceleration (a) with displacement



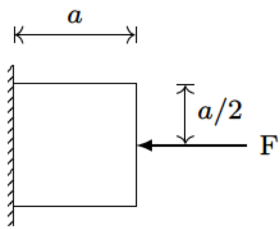
(A)


(B)


(C)


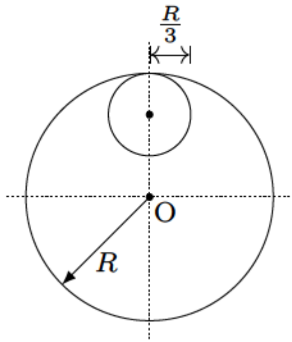
(D)


Q 4. A block of mass m is at rest under the action of force F against a wall as shown in the figure. Which of the following statement is incorrect?



(A) $f = mg$, where f is the frictional force.
(B) $F = N$, where N is the normal reaction.
(C) F will not produce torque about centre of mass.
(D) N will not produce torque about centre of mass.

Q 5. From a circular disc of radius R and mass $9M$, a small disc of radius $R/3$ is removed. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through O is



(A) $4MR^2$ (B) $\frac{40}{9}MR^2$ (C) $10MR^2$ (D) $\frac{37}{9}MR^2$

Q 6. A particle moves in a circular path with decreasing speed. Choose the correct statement,

(A) Angular momentum remains constant.

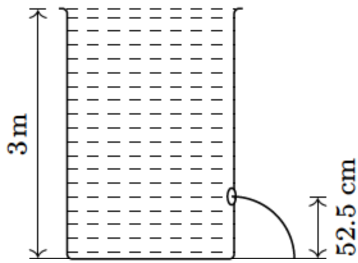
(B) Acceleration ($\vec{a}$) is towards the centre.

(C) Particle moves in a spiral path with decreasing radius.

(D) The direction of angular momentum remains constant.

Q 7. A simple pendulum has time period T_1. The point of suspension is now moved upwards according to the relation $y = kt^2$, ($k = 1\ \mathrm{m/s^2}$) where y is the vertical displacement. The time period now becomes T_2. The ratio of ${T_1}^2/{T_2}^2$ is [Take $g = 10\ \mathrm{m/s^2}$.]
(A) 6/5 (B) 5/6 (C) 1 (D) 4/5

Q 8. Water is filled in a beaker upto a height of 3 m. An orifice (hole) is at a height of 52.5 cm from the bottom of beaker (see figure). The ratio of cross-sectional area of the orifice and the beaker is 0.1. The square of the speed of the liquid coming out from the orifice is [Take $g = 10\ \mathrm{m/s^2}$.]



(A) $50\ (\mathrm{m/s})^2$ (B) $50.5\ (\mathrm{m/s})^2$
(C) $51\ (\mathrm{m/s})^2$ (D) $52\ (\mathrm{m/s})^2$

Q 9. The pressure of a medium is changed from 1.01×10^5 Pa to 1.165×10^5 Pa and change in volume is 10% keeping temperature constant at 20 °C. The bulk modulus of the medium is

(A) 204.8×10^5 Pa (B) 102.4×10^5 Pa

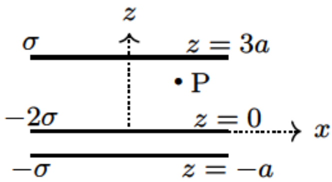
(C) 51.2×10^5 Pa (D) 1.55×10^5 Pa

Q 10. An infinitely long cylinder is kept parallel to a uniform magnetic field B directed along positive z-axis. The direction of induced current as seen from the +ve z-axis will be

(A) clockwise (B) anticlockwise

(C) zero (D) along the magnetic field

Q 11. Three infinitely long charge sheets are placed parallel to x-y plane as shown in the figure. The electric field at point P is

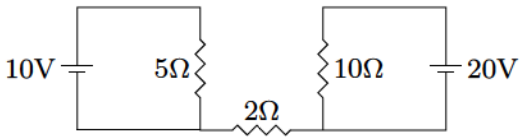


(A) $\frac{2\sigma}{\epsilon_0}\hat{k}$ (B) $-\frac{2\sigma}{\epsilon_0}\hat{k}$ (C) $\frac{4\sigma}{\epsilon_0}\hat{k}$ (D) $-\frac{4\sigma}{\epsilon_0}\hat{k}$

Q 12. A 4 μF capacitor and a 2.5 MΩ resistance are in series with 12 V battery. Find the time after which the potential difference across the capacitor is 3 times the potential difference across the resistor. [Given $\ln 2 = 0.693$]

(A) 13.86 s (B) 6.93 s (C) 7 s (D) 14 s

Q 13. Find out the value of current through 2 Ω resistance for the given circuit.



(A) 5 A (B) 2 A (C) zero (D) 4 A

Q 14. Ideal gas is contained in a thermally insulated and rigid container and it is heated through a resistance of 100 Ω by passing a current of 1 A. Change in internal energy of the gas after 5 min will be
(A) zero (B) 10 kJ (C) 20 kJ (D) 30 kJ

Q 15. A photon collides with a stationary hydrogen atom in ground state inelastically. Energy of the colliding photon is 10.2 eV. After a time interval of few micro-seconds another photon collides with same hydrogen atom inelastically with an energy of 15 eV. What will be observed by the detector?

(A) Two photons of energy 10.2 eV.

(B) Two photons of energy 1.4 eV.

(C) One photon of energy 10.2 eV and an electron of energy 1.4 eV.

(D) One photon of energy 10.2 eV and another photon of energy 1.4 eV.

Q 16. A tuning fork of 512 Hz is used to produce resonance in a resonance tube experiment. The level of water at first resonance is 30.7 cm and at second resonance is 63.2 cm. The error in calculating velocity of sound is [Speed of sound = 330 m/s.]

(A) 204.1 cm/s (B) 110 cm/s
(C) 58 cm/s (D) 280 cm/s

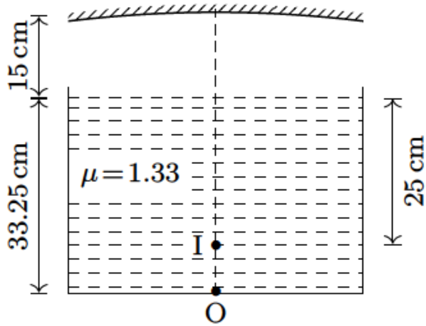
Q 17. An open pipe is in resonance in second harmonic with frequency f_1. Now one end of the tube is closed and frequency is increased to f_2 such that the resonance again occurs in n^{th} harmonic. Choose the correct option.

(A) $n = 3,\ f_2 = \frac{3}{4} f_1$ (B) $n = 3,\ f_2 = \frac{5}{4} f_1$
(C) $n = 5,\ f_2 = \frac{5}{4} f_1$ (D) $n = 5,\ f_2 = \frac{3}{4} f_1$

Q 18. A convex lens is in contact with concave lens. The magnitude of the ratio of their focal length is $3/2$. Their equivalent focal length is 30 cm. What are their individual focal lengths?

(A) -75 cm, 50 cm (B) -10 cm, 15 cm
(C) 75 cm, 50 cm (D) -15 cm, 10 cm

Q 19. A container is filled with water ($\mu = 1.33$) upto a height of 33.25 cm. A concave mirror is placed 15 cm above the water level and the image of an object placed at the bottom is formed 25 cm below the water level. The focal length of the mirror is



(A) 10 cm (B) 15 cm (C) 20 cm (D) 25 cm

Q 20. In Young's double slit experiment intensity at a point is one fourth of the maximum intensity. Angular position of this point is

(A) $\sin^{-1}\left(\frac{\lambda}{d}\right)$ (B) $\sin^{-1}\left(\frac{\lambda}{2d}\right)$

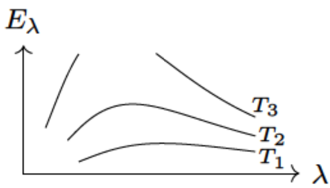
(C) $\sin^{-1}\left(\frac{\lambda}{3d}\right)$ (D) $\sin^{-1}\left(\frac{\lambda}{4d}\right)$

Q 21. A body with area A and emissivity $e = 0.6$ is kept inside a spherical black body. Total heat radiated by the body at temperature T is
(A) $0.6\sigma eAT^4$ (B) $0.8\sigma eAT^4$
(C) $1.0\sigma eAT^4$ (D) $0.4\sigma eAT^4$

Q 22. One calorie is defined as the amount of heat required to raise temperature of 1 g of water by 1 °C in a certain interval of temperature and at certain pressure. The temperature interval and pressure is

(A) from 14.5 °C to 15.5 °C at 760 mm of Hg
(B) from 98.5 °C to 99.5 °C at 760 mm of Hg
(C) from 13.5 °C to 14.5 °C at 76 mm of Hg
(D) from 3.5 °C to 4.5 °C at 76 mm of Hg

Q 23. Variation of radiant energy emitted by the sun, filament of tungsten lamp, and welding arc as a function of its wavelength is shown in the figure. Which of the following option gives the correct match?



(A) Sun-T_1, tungsten filament-T_2, welding arc-T_3
(B) Sun-T_2, tungsten filament-T_1, welding arc-T_3
(C) Sun-T_3, tungsten filament-T_2, welding arc-T_1
(D) Sun-T_1, tungsten filament-T_3, welding arc-T_2

Q 24. In which of the following process, convection does not take place primarily?
(A) Sea and land breeze.
(B) Boiling of water.
(C) Warming of glass bulb through filament.
(D) Circulation of air around furnace.

Q 25. Water of volume 2 litre in a container is heated with a coil of 1 kW at 27 °C. The lid of the container is open and energy dissipates at rate of 160 J/s. In how much time temperature will rise from 27 °C to 77 °C? [Specific heat of water is 4.2 kJ/(kg°C).]

(A) 8 min 20 s (B) 6 min 2 s

(C) 7 min (D) 14 min

Q 26. If a star converts all of its He into oxygen, find the amount of energy released per nucleus of oxygen. (Mass of the helium nucleus is 4.0026 u and mass of oxygen nucleus is 15.9994 u).

(A) 7.6 MeV (B) 56.12 MeV
(C) 10.24 MeV (D) 23.4 MeV

Q 27. A beam of electron is used in a Young's double slit experiment. The slit width is d. When the velocity of electron is increased,

(A) no interference is observed

(B) fringe width increases

(C) fringe width decreases

(D) fringe width remains same

Q 28. K_α wavelength emitted by an atom of atomic number $Z = 11$ is λ. The atomic number of an atom that emits K_α radiation with wavelength 4λ is
(A) 6 (B) 4 (C) 11 (D) 44

Answers

1. A
2. D
3. A
4. D
5. A
6. D
7. A
8. A
9. D
10. C
11. B
12. A
13. C
14. D
15. C
16. D
17. C
18. D
19. C
20. C
21. C
22. A
23. B
24. C
25. A
26. C
27. C
28. A

Main Paper

The main paper in physics is of 2 hour duration. It has 18 questions of total marks 60.

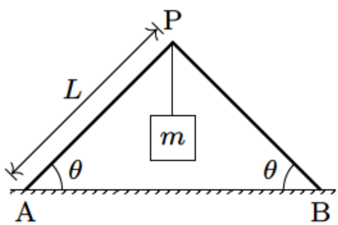
Descriptive

There are 18 questions in total. Solve all of them. There are 8 questions of two marks each, 8 questions of four marks each and 2 questions of six marks each.

Q 1. A conducting bubble of radius a and thickness t $(t \ll a)$ has potential V. Now the bubble collapses into a droplet. Find the potential of the droplet.

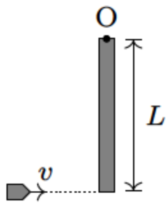
Q 2. The edge of a cube is measured using a Vernier calipers (9 divisions of the main scale are equal to 10 divisions of Vernier scale and 1 main scale division is 1 mm). The main scale division reading is 10 and first division of Vernier scale was found to be coinciding with the main scale. The mass of the cube is 2.736 g. Calculate the density in g/cm^3 upto correct significant figures.

Q 3. Two identical ladders, each of mass M and length L are resting on the rough horizontal surface as shown in the figure. A block of mass m hangs from P. If the system is in equilibrium, find the direction and magnitude of frictional force acting at A and B.

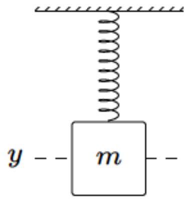


Q 4. A solid cylinder rolls without slipping on an inclined plane inclined at an angle θ. Find the linear acceleration of the cylinder. Mass of the cylinder is m.

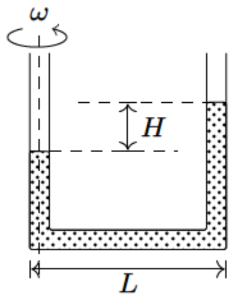
Q 5. A rod of length L and mass M is hinged at point O. A small bullet of mass m moving with velocity v hits the rod as shown in the figure. The bullet gets embedded in the rod. Find angular velocity of the system just after impact.



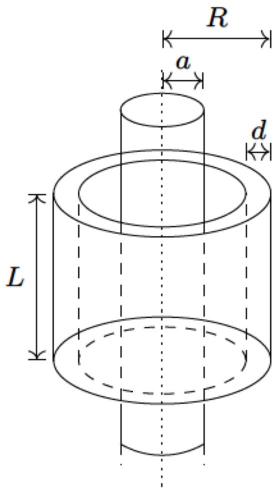
Q 6. A mass m is undergoing SHM in the vertical direction about the mean position y_0 with amplitude A and angular frequency ω. At a distance y from the mean position, the mass detaches from the spring. Assume that the spring contracts and does not obstruct the motion of m. Find the distance y (measured from the mean position) such that the height h attained by the block is maximum. $[A\omega^2 > g]$.



Q 7. A U-shaped tube contains a liquid of density ρ and it is rotated about the line as shown in the figure. Find the difference in height H of the liquid column. [Assume diameter of the tube $d \ll L$.]



Q 8. A long solenoid of radius a and number of turns per unit length n is enclosed by cylindrical shell of radius R, thickness d $(d \ll R)$ and length L. A variable current $i = i_0 \sin \omega t$ flows through the solenoid. If the resistivity of the material of cylindrical shell is ρ, find the induced current in the shell.



Q 9. In a moving coil galvanometer, torque on the coil can be expressed as $\tau = ki$, where i is the current through the wire and k is constant. The rectangular coil of the galvanometer having number of turns N, area A and moment of inertia I is placed in magnetic field B.

(a) Find k in terms of given parameters.

(b) If for current i_0 deflection is $\pi/2$, find out torsional constant of spring.

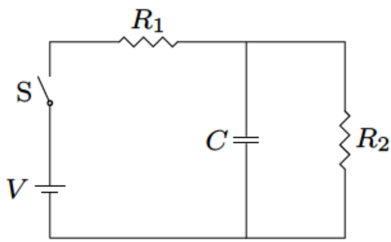
(c) If a charge Q is passed suddenly through the galvanometer, find the maximum angle of deflection.

Q 10. The potential energy of a particle varies as,

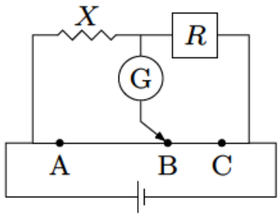
$$U(x) = \begin{cases} E_0 & \text{for } 0 \leq x \leq 1, \\ 0 & \text{for } x > 1. \end{cases}$$

For $0 \leq x \leq 1$, the de-Broglie wavelength is λ_1 and for $x > 1$, the de-Broglie wavelength is λ_2. Total energy of the particle is $2E_0$. Find λ_1/λ_2.

Q 11. At $t = 0$, switch S is closed (see figure). The charge on the capacitor is varying with time as $q = q_0\left(1 - e^{-\alpha t}\right)$. Obtain the value of q_0 and α in the given circuit parameters.



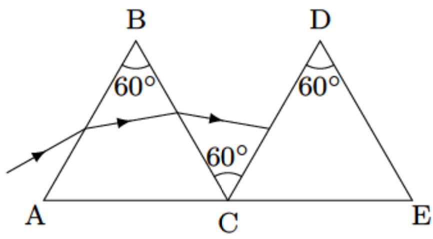
Q 12. R_1, R_2, R_3 are different values of resistor R and A, B, C are the null points obtained corresponding to R_1, R_2 and R_3, respectively. For which resistor, the value of X will be most accurate and why?



Q 13. A harmonically moving transverse wave on a string has a maximum particle velocity and acceleration of 3 m/s and 90 m/s^2 respectively. Velocity of the wave is 20 m/s. Find the waveform.

Q 14. An observer standing on a railway crossing receives frequency of 2.2 kHz and 1.8 kHz when the train approaches and recedes from the observer. Find the velocity of the train. [Speed of sound = 300 m/s.]

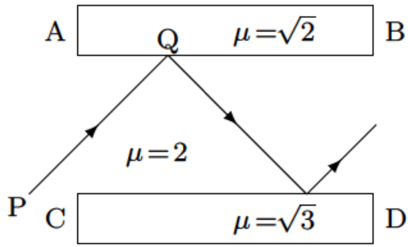
Q 15. A ray of light is incident on a prism ABC of refractive index $\sqrt{3}$ as shown in the figure.



(a) Find the angle of incidence for which the deviation of light ray by the prism ABC is minimum.

(b) By what angle the second identical prism must be rotated, so that the final ray suffers net minimum deviation.

Q 16. AB and CD are two slabs. The medium between the slabs has refractive index 2. Find the minimum angle of incidence at Q, so that the ray is totally reflected by the two slabs.



Q 17. A metal of mass 1 kg at constant atmospheric pressure and at initial temperature 20 °C is given a heat of 20000 J. Find (a) change in temperature (b) work done and (c) change in internal energy. [Given: Specific heat = 400 J/kg °C, coefficient of cubical expansion $\gamma = 9 \times 10^{-5}$ /°C, density $\rho = 9000\,\mathrm{kg/m^3}$, atmospheric pressure = $10^5\ \mathrm{N/m^2}$.]

Q 18. X-rays are incident on a target metal atom having 30 neutrons. The ratio of nuclear radius of the target atom to that of ${}^4_2\text{He}$ nucleus is $(14)^{1/3}$. [$R = 1.1 \times 10^7\ \text{m}^{-1}$, $c = 3 \times 10^8$ m/s.]

(a) Find the mass number of target atom.

(b) Find the frequency of K_α line emitted by this metal.

Answers

1. $V\left(\frac{a}{3t}\right)^{1/3}$

2. $2.66\ \mathrm{g/cm^3}$

3. $f=\left(\frac{M+m}{2}\right)g\cot\theta$

4. $\frac{2}{3}g\sin\theta$

5. $\frac{3mv}{L(3m+M)}$

6. g/ω^2

7. $H=\frac{\omega^2L^2}{2g}$

8. $\frac{\mu_0 Ldna^2 i_0\omega\cos\omega t}{2\rho R}$

9. (a) BNA (b) $\frac{2Bi_0NA}{\pi}$ (c) $Q\sqrt{\frac{BNA\pi}{2Ii_0}}$

10. $\sqrt{2}$

11. $q_0=\frac{CVR_2}{R_1+R_2}$, $\alpha=\frac{R_1+R_2}{CR_1R_2}$

12. R_2

13. $y=0.1\sin\left(30t\pm\frac{3}{2}x+\right.$

14. $30\ \mathrm{m/s}$

15. (a) $60°$ (b) $60°$

16. $60°$

17. (a) $50\ °\mathrm{C}$ (b) $0.05\ \mathrm{J}$ (c) $19999.95\ \mathrm{J}$

18. (a) 56 (b) 1.55×10^{18} H

IIT JEE 2004

IIT JEE 2004 has a screening paper and a main paper.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

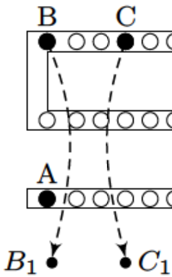
Screening Paper

The physics part of screening paper has 28 objective questions of the single option correct type.

One Option Correct

Each question has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. For the post office box arrangement to determine the value of unknown resistance, the unknown resistance should be connected between



(A) B and C (B) C and D
(C) A and D (D) B_1 and C_1

Q 2. A wire has a mass $m = 0.3 \pm 0.003$ g, radius $r = 0.5 \pm 0.005$ mm and length $l = 6 \pm 0.06$ cm. The maximum percentage error in the measurement of its density is

(A) 1 (B) 2 (C) 3 (D) 4

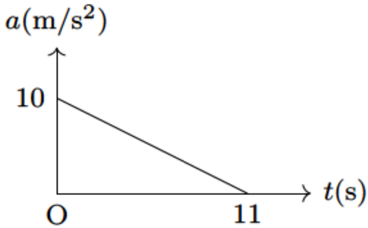
Q 3. In the relation $p = \frac{\alpha}{\beta} e^{-\frac{\alpha Z}{k\theta}}$, p is pressure, Z is distance, k is Boltzmann constant and θ is temperature. The dimensional formula of β is

(A) $[\mathrm{M^0L^2T^0}]$ (B) $[\mathrm{ML^2T^1}]$

(C) $[\mathrm{ML^0T^{-1}}]$ (D) $[\mathrm{M^0L^2T^{-1}}]$

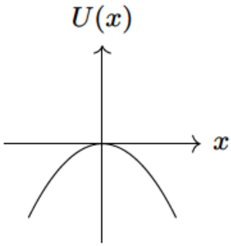
Q 4. A small block slides without friction down an inclined plane starting from rest. Let s_n be the distance travelled from $t = n - 1$ to $t = n$. Then $\frac{s_n}{s_{n+1}}$ is
(A) $\frac{2n-1}{2n}$ (B) $\frac{2n+1}{2n-1}$ (C) $\frac{2n-1}{2n+1}$ (D) $\frac{2n}{2n+1}$

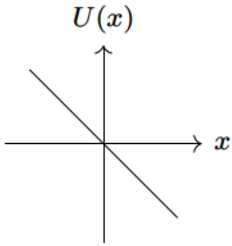
Q 5. A particle starts from rest. Its acceleration a (in m/s^2) *versus* time t (in s) is as shown in the figure. The maximum speed of the particle will be

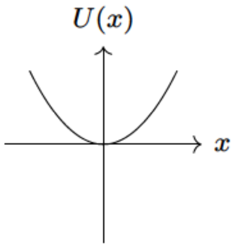


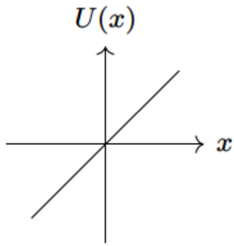
(A) 110 m/s (B) 55 m/s (C) 550 m/s (D) 660 m/s

Q 6. A particle is placed at the origin and a force $F = kx$ is acting on it (where k is a positive constant). If $U(0) = 0$, the graph of $U(x)$ *versus* x will be (where U is the potential energy function),

(A)


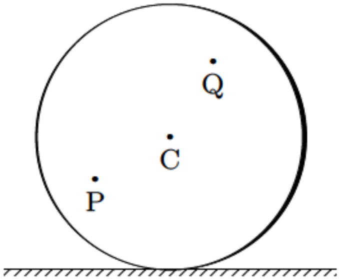
(B)


(C)


(D)


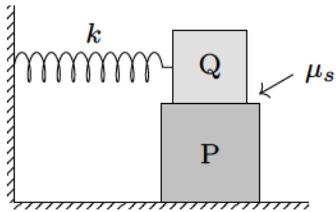
Q 7. A child is standing with folded hands at the centre of a platform rotating about its central axis. The kinetic energy of the system is K. The child now stretches his arms so that the moment of inertia of the system doubles. The kinetic energy of the system now is
(A) $2K$ (B) $K/2$ (C) $K/4$ (D) $4K$

Q 8. A disc is rolling (without slipping) on a horizontal surface. P and Q are two points equidistant from the centre C. Let v_P, v_Q and v_C be the magnitude of velocities of points P, Q and C respectively, then,



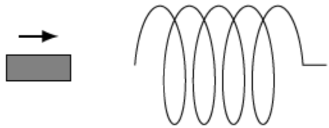
(A) $v_Q > v_C > v_P$ (B) $v_Q < v_C < v_P$
(C) $v_Q = v_P$, $v_C = v_P/2$ (D) $v_Q < v_C > v_P$

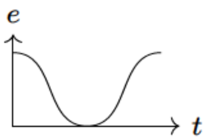
Q 9. A block P of mass m is placed on a horizontal frictionless plane. A second block of same mass m is placed on it and is connected to a spring of spring constant k. Then two blocks are pulled by a distance A. Block Q oscillates without slipping. What is the maximum value of frictional force between the two blocks?

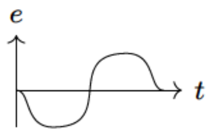


(A) $kA/2$ (B) kA (C) $\mu_s mg$ (D) zero

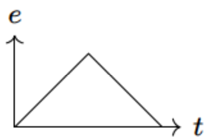
Q 10. The variation of the induced *emf* (e) with time (t) in a coil if a short bar magnet is moving along its axis with a constant velocity is best represented as



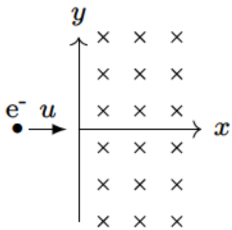
(A) 

(B) 

(C) 

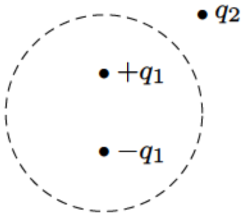
(D) 

Q 11. An electron moving with a speed u along the positive x-axis at $y = 0$ enters a region of uniform magnetic field $\vec{B} = -B_0\hat{k}$ which exists to the right of y-axis. The electron exits from the region after sometime with the speed v at coordinate y, then



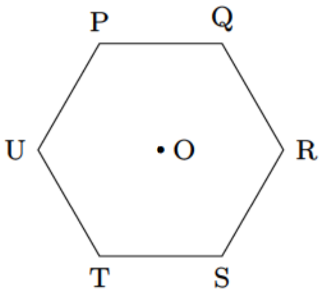
(A) $v > u,\ y < 0$ (B) $v = u,\ y > 0$
(C) $v > u,\ y > 0$ (D) $v = u,\ y < 0$

Q 12. Consider the charge configuration and a spherical Gaussian surface as shown in the figure. When calculating the flux of the electric field over the spherical surface, the electric field will be due to



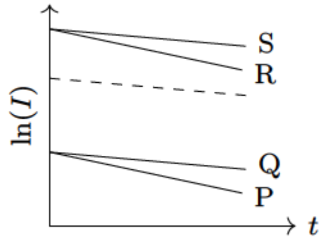
(A) q_2 (B) only the positive charges
(C) all the charges (D) $+q_1$ and $-q_1$

Q 13. Six charges, three positive and three negative of equal magnitude are to be placed at the vertices of a regular hexagon such that the electric field at O is double the electric field when only one positive charge of same magnitude is placed at R. Which of the following arrangements of charge is possible for P, Q, R, S, T and U respectively,



(A) $+, -, +, -, -, +$ (B) $+, -, +, -, +, -$
(C) $+, +, -, +, -, -$ (D) $-, +, +, -, +, -$

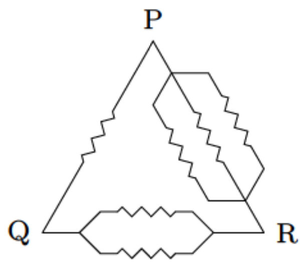
Q 14. A capacitor is charged using an external battery with a resistance x in series. The dashed line shows the variation of $\ln I$ with respect to time. If the resistance is changed to $2x$, the new graph will be



(A) P (B) Q (C) R (D) S

Q 15. After 280 days, the activity of a radioactive sample is 6000 disintegrations per second. The activity reduces to 3000 disintegration per second after another 140 days. The initial activity of the sample (in disintegration per second) is
(A) 6000 (B) 9000 (C) 3000 (D) 24000

Q 16. Six equal resistances are connected between points P, Q and R as shown in the figure. Then, the net resistance will be maximum between



(A) P and Q (B) Q and R
(C) P and R (D) any two points

Q 17. A pipe of length l_1, closed at one end is kept in a chamber of gas of density ρ_1. A second pipe open at both ends is placed in a second chamber of gas of density ρ_2. The compressibility of both the gases is equal. Calculate the length of the second pipe if frequency of first overtone in both the cases is equal.

(A) $l_1/3$ (B) $4l_1/3$ (C) $\frac{4l_1}{3}\sqrt{\frac{\rho_1}{\rho_2}}$ (D) $\frac{4l_1}{3}\sqrt{\frac{\rho_2}{\rho_1}}$

Q 18. A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1500 m/s and in air it is 300 m/s. The frequency of sound recorded by an observer who is standing in air is
(A) 200 Hz (B) 3000 Hz (C) 120 Hz (D) 600 Hz

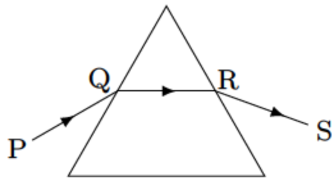
Q 19. In a Young's double slit experiment, bi-chromatic light of wavelength 400 nm and 560 nm are used. The distance between the slits is 0.1 mm and the distance between the plane of the slits and the screen is 1 m. The minimum distance between two successive regions of complete darkness is

(A) 4 mm (B) 5.6 mm (C) 14 mm (D) 28 mm

Q 20. A point object is placed at the centre of a glass sphere of radius 6 cm and refractive index 1.5. The distance of the virtual image from the surface of the sphere is

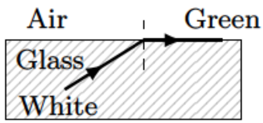
(A) 2 cm (B) 4 cm (C) 6 cm (D) 12 cm

Q 21. A ray of light is incident on an equilateral glass prism placed on a horizontal table. For minimum deviation which of the following is true?



(A) PQ is horizontal
(B) QR is horizontal
(C) RS is horizontal
(D) Either PQ or RS is horizontal

Q 22. White light is incident on the interface of glass and air as shown in the figure. If green light is just totally internally reflected then the emerging ray in air contains



(A) yellow, orange, red
(B) violet, indigo, blue
(C) all colours
(D) all colours except green

Q 23. Three discs, A, B and C having radii 2 m, 4 m and 6 m, respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are 300 nm, 400 nm and 500 nm, respectively. The power radiated by them are Q_A, Q_B and Q_C. Then,

(A) Q_A is maximum (B) Q_B is maximum

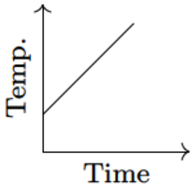
(C) Q_C is maximum (D) $Q_A = Q_B = Q_C$

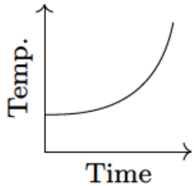
Q 24. Two identical conducting rods are first connected independently to two vessels, one containing water at 100 °C and the other containing ice at 0 °C. In the second case, the rods are joined end to end and connected to the same vessels. Let q_1 and q_2 grams per second be the rate of melting of ice in the two cases, respectively. The ratio q_1/q_2 is
(A) 1/2 (B) 2 (C) 4 (D) 1/4

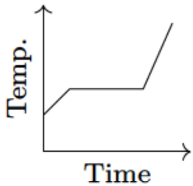
Q 25. An ideal gas expands isothermally from a volume V_1 to V_2 and then compressed to original volume V_1 adiabatically. Initial pressure is p_1 and final pressure is p_3. The total work done is W. Then,

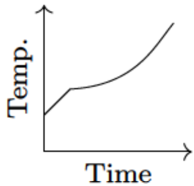
(A) $p_3 > p_1, W > 0$ (B) $p_3 < p_1, W < 0$
(C) $p_3 > p_1, W < 0$ (D) $p_3 = p_1, W = 0$

Q 26. Liquid oxygen at 50 K is heated to 300 K at constant pressure of 1 atm. The rate of heating is constant. Which of the following graphs represent the variation of temperature with time?

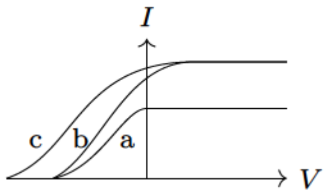
(A) 

(B) 

(C) 

(D) 

Q 27. The figure shows the variation of photocurrent with anode potential for a photosensitive surface for three different radiations. Let I_a, I_b and I_c be the intensities and f_a, f_b and f_c be the frequencies for the curves a, b and c respectively. Then,



(A) $f_a = f_b$ and $I_a \neq I_b$ (B) $f_a = f_c$ and $I_a = I_c$
(C) $f_a = f_b$ and $I_a = I_b$ (D) $f_b = f_c$ and $I_b = I_c$

Q 28. A proton has kinetic energy $E = 100$ keV which is equal to energy of a photon. Let λ_1 be the de-Broglie wavelength of the proton and λ_2 be the wavelength of the photon. The ratio λ_1/λ_2 is proportional to
(A) E^0 (B) $E^{1/2}$ (C) E^{-1} (D) E^{-2}

Answers

1. C
2. D
3. A
4. C
5. B
6. A
7. B
8. A
9. A
10. B
11. D
12. C
13. D
14. B
15. D
16. A
17. C
18. D
19. D
20. C
21. B
22. A
23. B
24. C
25. C
26. C
27. A
28. B

Main Paper

The main paper in physics is of 2 hour duration. It has 20 questions of total marks 60.

Descriptive

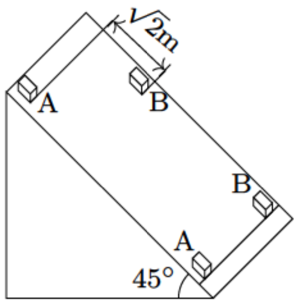
There are 20 questions in total. Solve all of them. The maximum marks for 10 questions is 2 and remaining 10 questions is 4.

Q 1. A proton and an alpha particle, after being accelerated through same potential difference, enter uniform magnetic field, the direction of which is perpendicular to their velocities. Find the ratio of radii of the circular paths of the two particles.

Q 2. The pitch of a screw gauge is 1 mm and there are 100 divisions on the circular scale. While measuring the diameter of a wire, the linear scale reads 1 mm and 47^{th} division on the circular scale coincides with the reference line. The length of the wire is 5.6 cm. Find the curved surface area (in cm^2) of the wire in appropriate number of significant figures.

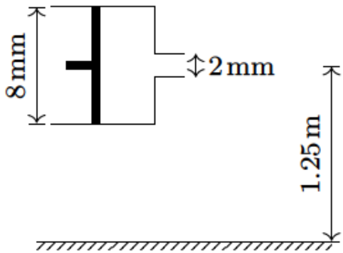
Q 3. In a Searle's experiment, the diameter of the wire as measured by a screw gauge of least count 0.001 cm is 0.050 cm. The length, measured by a scale of least count of 0.1 cm, is 110.0 cm. When a weight of 50 N is suspended from the wire, the extension is measured to be 0.125 cm by a micrometer of least count 0.001 cm. Find the maximum error in the measurement of Young's modulus of the material of wire from these data.

Q 4. Two blocks A and B of equal masses are released from an inclined plane of inclination 45° at $t = 0$. Both the blocks are initially at rest. The coefficient of kinetic friction between the block A and the inclined plane is 0.2 while it is 0.3 for the block B. Initially the block A is $\sqrt{2}$ m behind the block B. When and where their front faces will come in a line. [Take $g = 10\ \mathrm{m/s^2}$.]



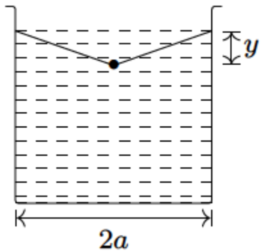
Q 5. A solid sphere of radius R is floating in a liquid of density ρ with half of its volume submerged. If the sphere is slightly pushed and released, it starts performing SHM. Find the frequency of these oscillations.

Q 6. Consider a horizontally oriented syringe containing water located at a height of 1.25 m above the ground. The diameter of the plunger is 8 mm and the diameter of the nozzle is 2 mm. The plunger is pushed with a constant speed of 0.25 m/s. Find the horizontal range of water stream on the ground.

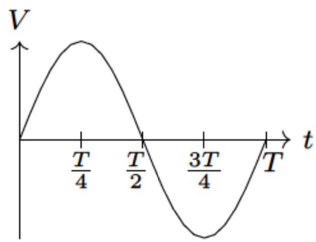


Q 7. A small sphere falls from rest in a viscous liquid. Due to friction, heat is produced. Find the relation between the rate of production of heat and the radius of the sphere at terminal velocity.

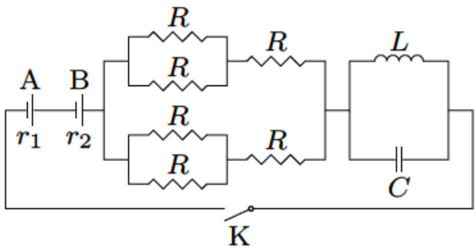
Q 8. A container of width $2a$ is filled with a liquid. A thin wire of mass per unit length λ is gently placed over the liquid surface in the middle of the surface as shown in the figure. As a result, the liquid surface is depressed by a distance y ($\ll a$). Determine the surface tension of the liquid.



Q 9. In an L-R series circuit, a sinusoidal voltage $V = V_0 \sin \omega t$ is applied. It is given that $L = 35\,\text{mH}$, $R = 11\,\Omega$, $V_{\text{rms}} = 220$ V, $\omega/(2\pi) = 50$ Hz, and $\pi = 22/7$. Find the amplitude of current in the steady state and obtain the phase difference between the current and the voltage. Also plot the variation of current for one cycle on the given graph.

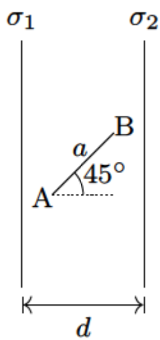


Q 10. In the circuit shown A and B are two cells of same *emf* E but different internal resistances r_1 and $r_2 (r_1 > r_2)$ respectively. Find the value of R such that the potential difference across the terminals of cell A is zero a long time after the key K is closed.



Q 11. A rock is 1.5×10^9 yr old. The rock contains ^{238}U which disintegrates to form ^{206}Pb. Assume that there was no ^{206}Pb in the rock initially and it is the only stable product formed by the decay. Calculate the ratio of number of nuclei of ^{238}U to that of ^{206}Pb in the rock. [Half life of ^{238}U is 4.5×10^9 yr (Take $2^{1/3} = 1.259$).]

Q 12. Two large parallel metallic plates S_1 and S_2 carrying surface charge densities σ_1 and σ_2 respectively $(\sigma_1 > \sigma_2)$ are placed at a distance d apart in vacuum. Find the work done by the electric field in moving a point charge q a distance a $(a < d)$ from S_1 towards S_2 along a line making an angle $\pi/4$ with the normal to the plates.

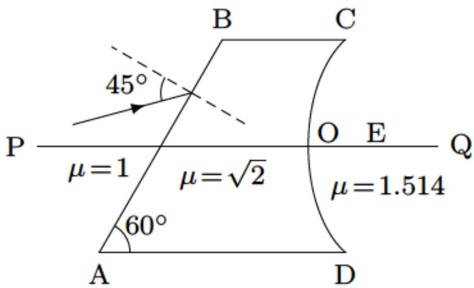


Q 13. Draw the circuit for experimental verification of Ohm's law using a source of variable DC voltage, a main resistance of $100\ \Omega$, two galvanometers and two resistances of values $10^6\ \Omega$ and $10^{-3}\ \Omega$, respectively. Clearly show the positions of the voltmeter and the ammeter.

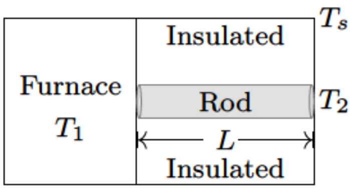
Q 14. In a Young's double slit experiment, two wavelengths of 500 nm and 700 nm were used. What is the minimum distance from the central maximum where their maxima coincide again? Take $D/d = 10^3$. Symbols have their usual meaning.

Q 15. An object is approaching a thin convex lens of focal length 0.3 m with a speed of 0.01 m/s. Find the magnitudes of the rate of change of position and rate of change of lateral magnification, of image when the object is at a distance of 0.4 m from the lens.

Q 16. Figure shows an irregular block of material of refractive index $\sqrt{2}$. A ray of light strikes the face AB as shown in the figure. After refraction it is incident on a spherical surface CD of radius of curvature 0.4 m and enters a medium of refractive index 1.514 to meet PQ at E. Find the distance OE upto two places of decimal.

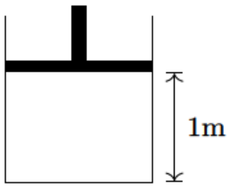


Q 17. One end of a rod of length L and cross-sectional area A is kept in a furnace of temperature T_1. The other end of the rod is kept at temperature T_2. The thermal conductivity of the material of the rod is K and emissivity of the rod is e. It is given that $T_2 = T_s + \Delta T$, where $\Delta T \ll T_s$, T_s being the temperature of the surroundings. If $\Delta T \propto (T_1 - T_s)$, find the proportionality constant. Consider that heat is lost only by radiation at the end where the temperature of the rod is T_2.



Q 18. A cube of coefficient of linear expansion α_s is floating in a bath containing a liquid of coefficient of volume expansion γ_l. When the temperature is raised by ΔT, the depth up to which the cube is submerged in the liquid remains the same. Find the relation between α_s and γ_l showing all the steps.

Q 19. The piston cylinder arrangement shown in the figure contains a diatomic gas at temperature 300 K. The cross-sectional area of the cylinder is 1 m^2. Initially the height of the piston above the base of the cylinder is 1 m. The temperature is now raised to 400 K at constant pressure. Find the new height of the piston above the base of the cylinder. If the piston is now brought back to its original height without any heat loss, find the new equilibrium temperature of the gas. You can leave the answer in fraction.



Q 20. Wavelength belonging to Balmer series, lying in the range of 450 nm to 750 nm, were used to eject photoelectrons from a metal surface whose work function is 2.0 eV. Find (in eV) the maximum kinetic energy of the emitted photoelectrons. [Take $hc = 1242$ eV nm.]

Answers

1. $1/\sqrt{2}$

2. 2.6 cm^2

3. 1.09×10^{10} N/m^2

4. $S_A = 8\sqrt{2}$ m, 2 s

5. $\frac{1}{2\pi}\sqrt{\frac{3g}{2R}}$

6. 2 m

7. $\frac{\mathrm{d}Q}{\mathrm{d}t} \propto r^5$

8. $\frac{\lambda g a}{2y}$

9. 20 A, $\pi/4$

10. $R = \frac{4}{3}(r_1 - r_2)$

11. 3.861

12. $\frac{(\sigma_1-\sigma_2)qa}{\sqrt{2}\epsilon_0}$

13. See solution.

14. 3.5 mm

15. 0.09 m/s, -0.3 s^{-1}

16. 6.06 m

17. $\frac{K}{4e\sigma L T_s^3 + K}$

18. $\gamma_l = 2\alpha_s$

19. 4/3 m, 448.8 K

20. 0.55 eV

IIT JEE 2003

IIT JEE 2003 has a screening paper and a main paper.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

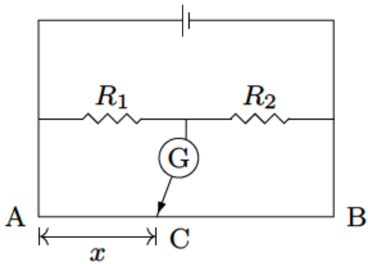
Screening Paper

The physics part of screening paper has 28 objective questions of the single option correct type.

One Option Correct

Each question has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. In the shown arrangement of the experiment of the meter bridge if AC corresponding to null deflection of galvanometer is x, what should be its value if the radius of the wire AB is doubled?



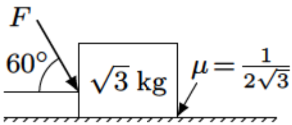
(A) x (B) $x/4$ (C) $4x$ (D) $2x$

Q 2. The edge of a cube is measured to be 1.2×10^{-2} m. Its volume should be recorded as

(A) $1.7 \times 10^{-6}\ \mathrm{m}^3$ (B) $1.73 \times 10^{-6}\ \mathrm{m}^3$

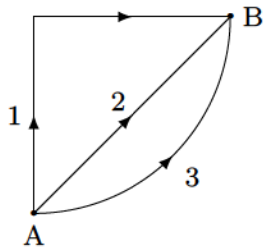
(C) $1.70 \times 10^{-6}\ \mathrm{m}^3$ (D) $1.728 \times 10^{-6}\ \mathrm{m}^3$

Q 3. What is the maximum value of the force F such that the block shown in the arrangement does not move? [Take $g = 10 \text{ m/s}^2$.]



(A) 20 N (B) 10 N (C) 12 N (D) 15 N

Q 4. If W_1, W_2 and W_3 represent the work done in moving a particle from A to B along three different paths 1, 2 and 3 respectively (see figure) in the gravitational field of a point mass m. Find the correct relation between W_1, W_2 and W_3.

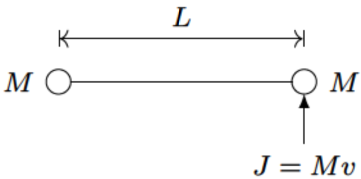


(A) $W_1 > W_2 > W_3$ (B) $W_1 = W_2 = W_3$
(C) $W_1 < W_2 < W_3$ (D) $W_2 > W_1 > W_3$

Q 5. A particle undergoes uniform circular motion. About which point on the plane of the circle, will the angular momentum of the particle remain conserved?

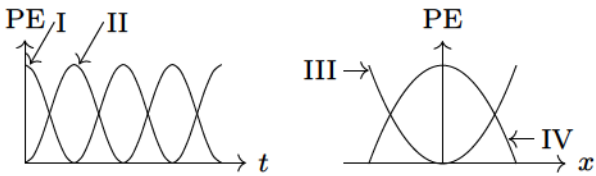
(A) centre of the circle.
(B) on the circumference of the circle.
(C) inside the circle.
(D) outside the circle.

Q 6. Consider a body consisting of two identical balls, each of mass M connected by a light rigid rod of length L (see figure). If an impulse $J = Mv$ is imparted to the body at one of its end, what would be its angular velocity?



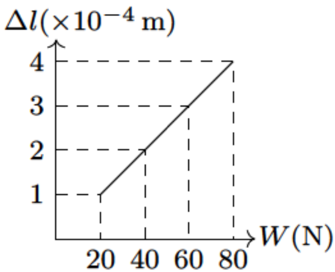
(A) $\frac{v}{L}$ (B) $\frac{2v}{L}$ (C) $\frac{v}{3L}$ (D) $\frac{v}{4L}$

Q 7. For a particle executing SHM, the displacement x is given by $x = A\cos\omega t$. Identify the graph which represents the variation of potential energy (PE) as a function of time t and displacement x,



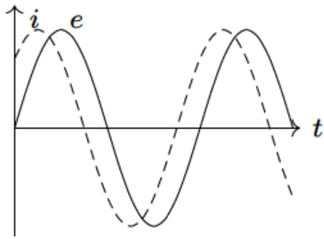
(A) I, III (B) II, IV (C) II, III (D) I, IV

Q 8. The adjacent graph shows the extension (Δl) of a wire of length 1 m suspended from the top of a roof at one end and with a load W connected to the other end. If the cross-sectional area of the wire is $10^{-6}\ \mathrm{m}^2$, calculate, from the graph, the Young's modulus of the material of the wire.



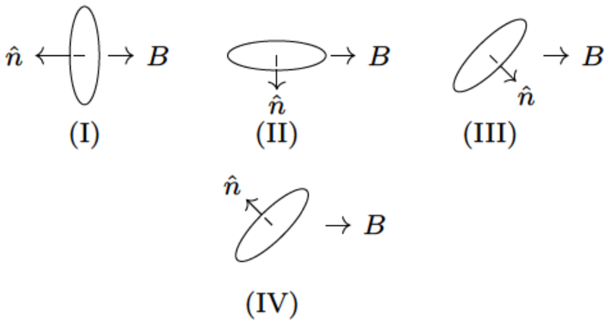
(A) $2 \times 10^{11}\ \mathrm{N/m^2}$ (B) $2 \times 10^{-11}\ \mathrm{N/m^2}$
(C) $3 \times 10^{12}\ \mathrm{N/m^2}$ (D) $2 \times 10^{13}\ \mathrm{N/m^2}$

Q 9. When an AC source of *emf* $e = e_0 \sin(100t)$ is connected across a circuit, the phase difference between the emf e and the current i in the circuit is observed to be $\pi/4$, as shown in the diagram. If the circuit consists possibly only R-C or R-L or L-C in series, find the relationship between the two elements.



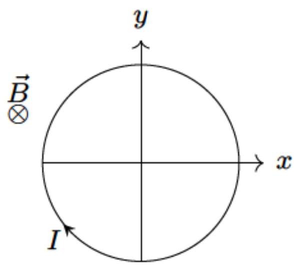
(A) $R = 1\ \mathrm{k\Omega}$, $C = 10\ \mu\mathrm{F}$ (B) $R = 1\ \mathrm{k\Omega}$, $C = 1\ \mu\mathrm{F}$
(C) $R = 1\ \mathrm{k\Omega}$, $L = 10\ \mathrm{H}$ (D) $R = 1\ \mathrm{k\Omega}$, $L = 1\ \mathrm{H}$

Q 10. A current carrying loop is placed in a uniform magnetic field in four different orientations, I, II, III and IV. Arrange them in the decreasing order of potential energy.



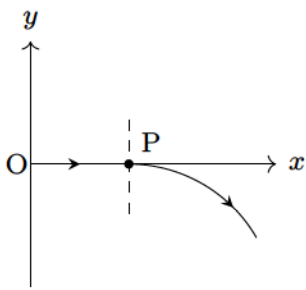
(A) I > III > II > IV (B) I > II > III > IV
(C) I > IV > II > III (D) III > IV > I > II

Q 11. A conducting loop carrying a current I is placed in a uniform magnetic field pointing into the plane of the paper as shown. The loop will have a tendency to



(A) contract
(B) expand
(C) move towards +ve x axis
(D) move towards −ve x axis

Q 12. For a positively charged particle moving in a x-y plane initially along the x-axis, there is a sudden change in its path due to the presence of electric and/or magnetic fields beyond P. The curved path is shown in the x-y plane and is found to be non-circular. Which of the following combination is possible? [Here a, b and c are non-zero positive constants.]

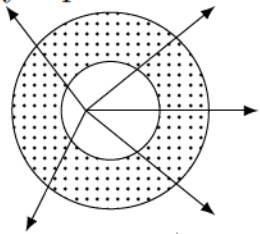


(A) $\vec{E} = 0$, $\vec{B} = b\hat{\jmath} + c\hat{k}$ (B) $\vec{E} = a\hat{\imath}$, $\vec{B} = c\hat{k} + b\hat{\imath}$

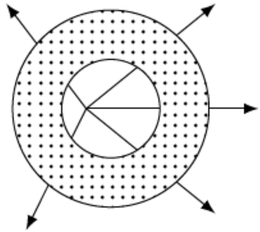
(C) $\vec{E} = 0$, $\vec{B} = c\hat{\jmath} + b\hat{k}$ (D) $\vec{E} = a\hat{\imath}$, $\vec{B} = c\hat{k} + b\hat{\jmath}$

Q 13. A metallic shell has a point charge q kept inside its cavity. Which one of the following diagrams correctly represents the electric lines of force?

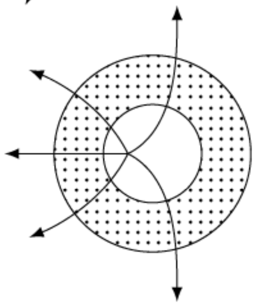
(A)



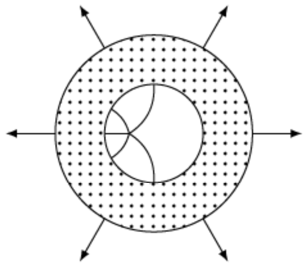
(B)



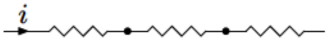
(C)



(D)

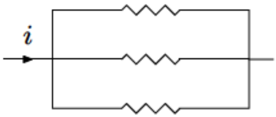


Q 14. The three resistances of equal value are arranged in the different combination shown below. Arrange them in increasing order of power dissipation.

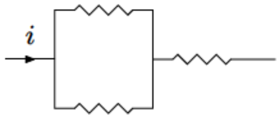


(I)

(II)



(III)



(IV)

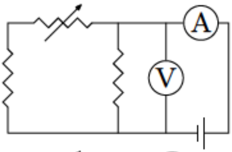
(A) III < II < IV < I   (B) II < III < IV < I

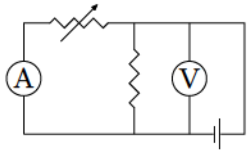
(C) I < IV < III < II   (D) I < III < II < IV

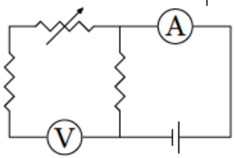
Q 15. The electric potential between a proton and an electron is given by $V = V_0 \ln\left(\frac{r}{r_0}\right)$, where V_0 and r_0 are constants. Assuming Bohr's model to be applicable, how does radius r_n of the n^{th} Bohr's orbit varies with the principal quantum number n?

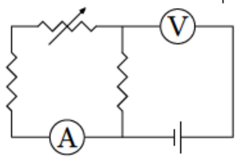
(A) $r_n \propto n$ (B) $r_n \propto \frac{1}{n}$ (C) $r_n \propto n^2$ (D) $r_n \propto \frac{1}{n^2}$

Q 16. Which of the following set-up can be used to verify Ohm's law?

(A) 

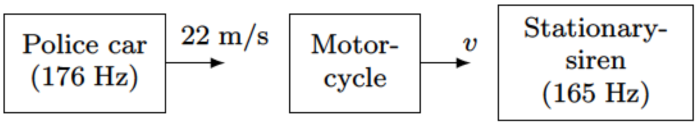
(B) 

(C) 

(D) 

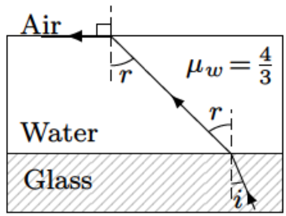
Q 17. In an experiment of the determination of the speed of sound in air using the resonance column method, the length of the air column that resonates in the fundamental mode, with a tuning fork is 0.1 m. When this length is changed to 0.35 m, the same tuning fork resonates with the first overtone. Calculate the end correction.
(A) 0.012 m (B) 0.025 m (C) 0.05 m (D) 0.024 m

Q 18. A police car moving at 22 m/s sounds a horn at 176 Hz while chasing a motor-cyclist. Both, police car and motor-cyclist, are moving towards a stationary siren of frequency 165 Hz. What is the speed of the motorcycle if it is given that the motor-cyclist does not observe beats? [Speed of sound = 330 m/s.]



(A) 33 m/s (B) 22 m/s (C) zero (D) 11 m/s

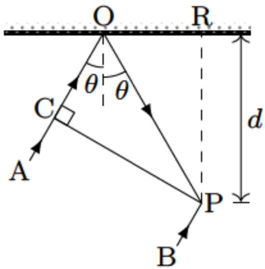
Q 19. A ray of light is incident at the glass-water surface at an angle i. It emerges finally parallel to the surface of water, then the value of glass refractive index μ_g would be



(A) $\frac{4}{3}\sin i$ (B) $\frac{1}{\sin i}$ (C) $4/3$ (D) 1

Q 20. The size of the image of an object, which is at infinity, as formed by a convex lens of focal length 30 cm is 2 cm. If a concave lens of focal length 20 cm is placed between the convex lens and the image at a distance of 26 cm from the convex lens, calculate the new size of the image.
(A) 1.25 cm (B) 2.5 cm (C) 1.05 cm (D) 2 cm

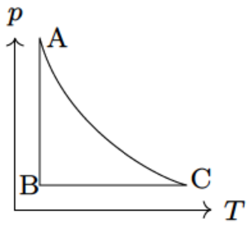
Q 21. In the adjacent diagram CP represents a wavefront and AO and BP, the corresponding two rays. Find the condition of θ for constructive interference at P between the ray BP and the reflected ray OP.

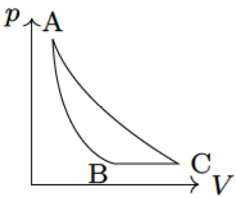


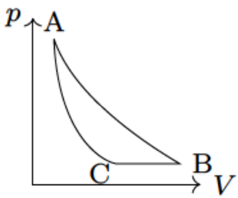
(A) $\cos\theta = \frac{3\lambda}{2d}$ (B) $\cos\theta = \frac{\lambda}{4d}$
(C) $\sec\theta - \cos\theta = \frac{\lambda}{d}$ (D) $\sec\theta - \cos\theta = \frac{4\lambda}{d}$

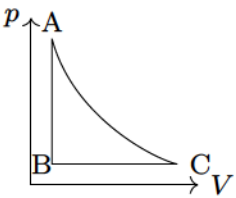
Q 22. 2 kg of ice at $-20\ ^\circ$C is mixed with 5 kg of water at $20\ ^\circ$C in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. It is given that the specific heats of water and ice are 1 kcal/(kg°C) and 0.5 kcal/(kg°C) while the latent heat of fusion of ice is 80 kcal/kg.
(A) 7 kg (B) 6 kg (C) 4 kg (D) 2 kg

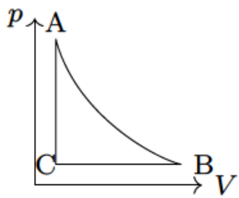
Q 23. The p-T diagram for an ideal gas is shown in the figure, where AC is an adiabatic process. Corresponding p-V diagram is given by



(A) 

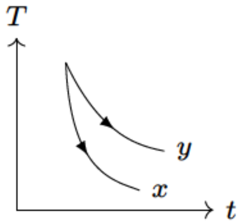
(B) 

(C) 

(D) 

Q 24. Two rods, one of aluminium and the other made of steel, having initial lengths l_1 and l_2 are connected together to form a single rod of length $l_1 + l_2$. The coefficients of linear expansion for aluminium and steel are α_a and α_s, respectively. If the length of each rod increases by the same amount when their temperature are raised by t°C, then find the ratio $\frac{l_1}{l_1+l_2}$,
(A) $\frac{\alpha_s}{\alpha_a}$ (B) $\frac{\alpha_a}{\alpha_s}$ (C) $\frac{\alpha_s}{\alpha_a+\alpha_s}$ (D) $\frac{\alpha_a}{\alpha_a+\alpha_s}$

Q 25. The temperature (T) *versus* time (t) graphs of two bodies X and Y with equal surface areas are shown in the figure. If the emissivity and the absorptivity of X and Y are E_x, E_y and a_x, a_y, respectively, then,



(A) $E_x > E_y$ and $a_x < a_y$
(B) $E_x < E_y$ and $a_x > a_y$
(C) $E_x > E_y$ and $a_x > a_y$
(D) $E_x < E_y$ and $a_x < a_y$

Q 26. A nucleus with mass number 220 initially at rest emits an α-particle. If the Q value of reaction is 5.5 MeV, calculate the kinetic energy of the α-particle.

(A) 4.4 MeV (B) 5.4 MeV
(C) 5.6 MeV (D) 6.5 MeV

Q 27. For uranium nucleus, its mass (m) vary with volume (V) as
(A) $m \propto V$ (B) $m \propto 1/V$ (C) $m \propto \sqrt{V}$ (D) $m \propto V^2$

Q 28. If the atom ${}_{100}\mathrm{Fm}^{257}$ follows the Bohr's model and the radius of ${}_{100}\mathrm{Fm}^{257}$ is n times the Bohr radius, then find n.
(A) 100 (B) 200 (C) 4 (D) 1/4

Answers

1. A
2. A
3. A
4. B
5. A
6. A
7. A
8. A
9. A
10. C
11. B
12. B
13. D
14. A
15. A
16. B
17. B
18. B
19. B
20. B
21. B
22. B
23. A
24. C
25. C
26. B
27. A
28. D

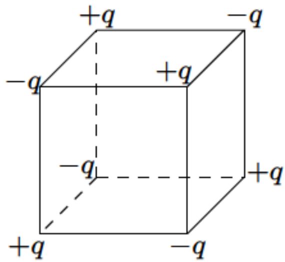
Main Paper

The main paper in physics is of 2 hour duration. It has 20 questions of total marks 60.

Descriptive

There are 20 questions in total. Solve all of them. The maximum marks for 10 questions is 2 and remaining 10 questions is 4.

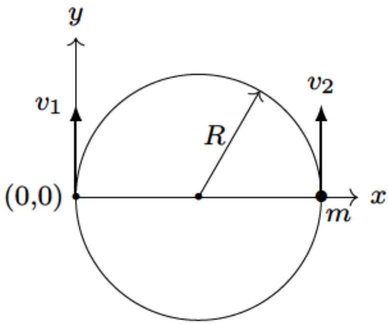
Q 1. Eight point charges are placed at the corners of a cube of edge a as shown in the figure. Find the work done in disassembling this system of charges.



Q 2. N divisions on the main scale of a Vernier calipers coincide with $(N + 1)$ divisions on its Vernier scale. If each division on the main scale is of a units, determine the least count of instrument.

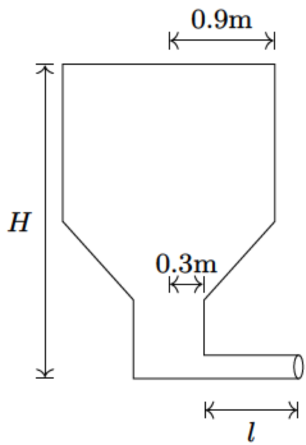
Q 3. Two point masses m_1 and m_2 are connected by a spring of spring constant k and natural length l_0. The spring is compressed such that the two point masses touch each other and then are fastened by a string. Then the system is moved with a velocity v_0 along positive x-axis. When the system reaches the origin the string breaks ($t = 0$). The position of the point mass m_1 is given by $x_1 = v_0 t - A(1 - \cos \omega t)$ where A and ω are constants. Find the position of the second block as a function of time. Also find the relation between A and l_0.

Q 4. A particle of mass m, moving in circular path of radius R with a constant speed v_2 is located at point $(2R, 0)$ at time $t = 0$. At the same instant, a man starts moving with a velocity v_1 along the positive y-axis. Calculate the linear momentum of the particle w.r.t. man as a function of time.

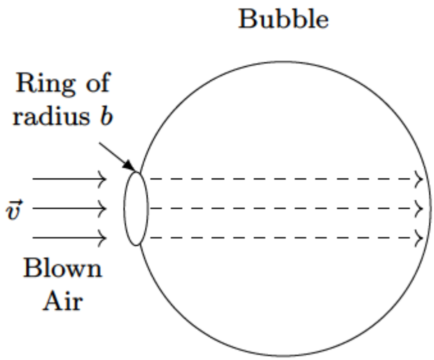


Q 5. There is a crater of depth $R/100$ on the surface of moon (radius R). A projectile is fired vertically upward from the crater with velocity equal to the escape velocity v from the surface of the moon. Find the maximum height attained by the projectile.

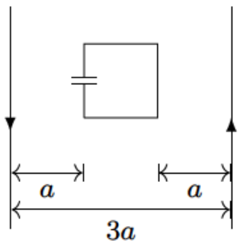
Q 6. A liquid of density 900 $\mathrm{kg/m^3}$ is filled in a cylindrical tank of upper radius 0.9 m and lower radius 0.3 m. A capillary tube of length l is attached at the bottom of the tank as shown in the figure. The capillary has outer radius 0.002 m and inner radius a. When pressure p is applied at the top of the tank volume flow rate of the liquid is $8 \times 10^{-6}\ \mathrm{m^3/s}$ and if capillary tube is detached, the liquid comes out from the tank with a velocity of 10 m/s. Determine the coefficient of viscosity of the liquid. [Given : $\pi a^2 = 10^{-6}\ \mathrm{m}^2$ and $a^2/l = 2 \times 10^{-6}$ m.]



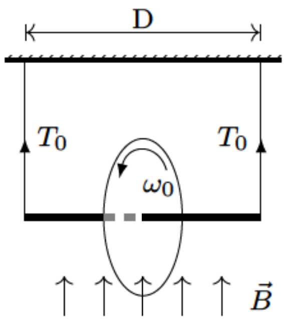
Q 7. A soap bubble is being blown at the end of a very narrow tube of radius b. Air (density ρ) moves with a velocity v inside the tube and comes to rest inside the bubble. The surface tension of the soap solution is T. After some time the bubble, having grown to a radius r, separates from the tube. Find the value of r. Assume that $r \gg b$ so that you can consider the air to be falling normally on the bubble's surface.



Q 8. Two infinitely long parallel wires carrying currents $I = I_0 \sin \omega t$ in opposite directions are placed a distance $3a$ apart. A square loop of side a of negligible resistance with a capacitor of capacitance C is placed in the plane of wires as shown. Find the maximum current in the square loop. Also sketch the graph showing the variation of charge on the upper plate of the capacitor as a function of time for one complete cycle taking anticlockwise direction for the current in the loop as positive.



Q 9. A ring of radius R having uniformly distributed charge Q is mounted on a rod suspended by two identical strings. The tension in strings in equilibrium is T_0. Now a vertical magnetic field is switched on and ring is rotated at constant angular velocity ω. Find the maximum ω with which the ring can be rotated if the strings can withstand a maximum tension of $\frac{3T_0}{2}$.



Q 10. A positive point charge q is fixed at origin. A dipole with a dipole moment $\vec{p}$ is placed along the x-axis far away from the origin with $\vec{p}$ pointing along positive x-axis. Find (a) the kinetic energy of the dipole when it reaches a distance r from the origin and (b) force experienced by the charge q at this moment.

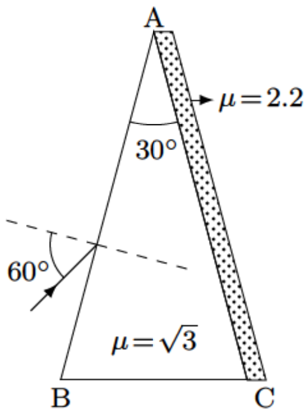
Q 11. Characteristic X-rays of frequency 4.2×10^{18} Hz are produced when transitions from L-shell to K-shell take place in a certain target material. Use Moseley's law to determine the atomic number of the target material. [Rydberg's constant $= 1.1 \times 10^{7}\ \mathrm{m}^{-1}$.]

Q 12. Show by diagram, how can we use a rheostat as the potential divider?

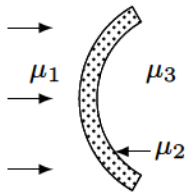
Q 13. A string of mass per unit length μ is clamped at both ends such that one end of the string is at $x = 0$ and the other is at $x = l$. When string vibrates in fundamental mode, amplitude of the mid-point O of the string is a, and tension in the string is T. Find the total oscillation energy stored in the string.

Q 14. In a resonance tube experiment to determine the speed of sound in air, a pipe of diameter 5 cm is used. The air column in pipe resonates with a tuning fork of frequency 480 Hz when the minimum length of the air column is 16 cm. Find the speed of sound in air at room temperature.

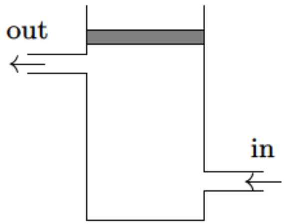
Q 15. A prism of refracting angle 30° is coated with a thin film of transparent material of refractive index 2.2 on face AC as shown in the figure. A light of wavelength 6600 Å is incident on face AB such that angle of incidence is 60°. Find, (a) the angle of emergence and (b) the minimum value of thickness of the coated film on the face AC for which the light emerging from the face has maximum intensity. [Given refractive index of the material of the prism is $\sqrt{3}$.]



Q 16. In the figure, light is incident on a thin lens as shown. The radius of curvature for both the surfaces is R. Determine the focal length of this system for $\mu_1 < \mu_2 < \mu_3$.



Q 17. The top of an insulated cylindrical container is covered by a disc having radiation emissivity 0.6, thermal conductivity 0.167 W m^{-1} K^{-1} and thickness 1 cm. The temperature is maintained by circulating oil as shown in the figure. The temperature of the upper surface of disc is 127 °C and temperature of the surrounding is 27 °C. Find (a) the rate of radiation loss to the surroundings by unit area of the disc and (b) the temperature of the circulating oil. Neglect the heat loss due to convection. [Given $\sigma = \frac{17}{3} \times 10^{-8}$ W m^{-2} K^{-4}.]



Q 18. An insulated box containing a monatomic gas of molar mass M moving with a speed v_0 is suddenly stopped. Find the increment in gas temperature as a result of stopping the box.

Q 19. In a photoelectric experiment set-up, photons of energy 5 eV falls on the cathode having work function 3 eV. If the saturation current $i_A = 4\ \mu\text{A}$ for intensity $I_A = 10^{-5}\ \text{W/m}^2$, then plot the variation of photocurrent i_p against the anode voltage V_a for photon intensity $I_A = 10^{-5}\ \text{W/m}^2$ and $I_B = 2 \times 10^{-5}\ \text{W/m}^2$.

Q 20. A radioactive element decays by β-emission. A detector records n beta particles in 2 s and in next 2 s it records $0.75n$ beta particles. Find mean life (in s) correct to nearest whole number. [Given $\ln 2 = 0.6931$, $\ln 3 = 1.0986$].

Answers

1. $\frac{5.824}{4\pi\epsilon_0}\frac{q^2}{a}$
2. $\frac{a}{N+1}$
3. $x_2 = v_0 t + \frac{m_1}{m_2} A\,(1 - \cos\omega t)$, $l_0 = (m_1/m_2 + 1)A$
4. $-mv_2 \sin\frac{v_2 t}{R}\hat{\imath} + m\big(v_2 \cos\frac{v_2 t}{R} - v_1\big)\hat{\jmath}$
5. $99.5R$
6. $\frac{1}{720}$ N s/m^2
7. $\frac{4T}{\rho v^2}$
8. $i_{\text{max}} = \frac{1}{\pi}\mu_0 C I_0 a\omega^2 \ln 2$
9. $\frac{DT_0}{BQR^2}$
10. (a) $\frac{qp}{4\pi\epsilon_0 r^2}$ (b) $\frac{pq}{2\pi\epsilon_0 r^3}\hat{\imath}$
11. 42
12. See solution.
13. $\pi^2 a^2 T/(4l)$
14. 336 m/s
15. (a) zero (b) 1500 Å
16. $\frac{\mu_3 R}{\mu_3 - \mu_1}$
17. (a) 595 W/m^2 (b) 162.6 °C
18. $\frac{Mv_0^2}{3R}$
19. See solution
20. 7 s

IIT JEE 2002

IIT JEE 2002 has a screening paper and a main paper.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Screening Paper

The physics part of screening paper has 30 objective questions of the single option correct type.

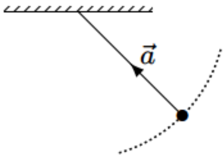
One Option Correct

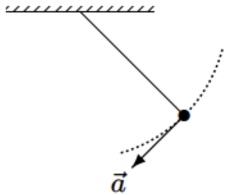
Each question has four options (A), (B), (C) and (D). Only one of these four options is correct.

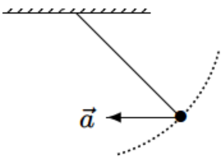
Q 1. Two equal point charges are fixed at $x = -a$ and $x = +a$ on the x-axis. Another point charge Q is placed at the origin. The change in the electrical potential energy of Q, when it is displaced by a small distance x along the x-axis, is approximately proportional to
(A) x (B) x^2 (C) x^3 (D) $1/x$

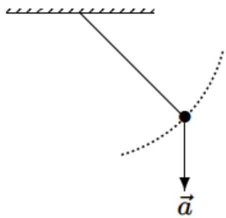
Q 2. A geostationary satellite orbits around the earth in a circular orbit of radius 36000 km. Then, the time period of a spy satellite orbiting a few hundred kilometers above the earth surface ($R_e = 6400$ km) will approximately be
(A) $\frac{1}{2}$ h (B) 1 h (C) 2 h (D) 4 h

Q 3. A simple pendulum is oscillating without damping. When the displacement of the bob is less than maximum, its acceleration vector $\vec{a}$ is correctly shown in

(A) 

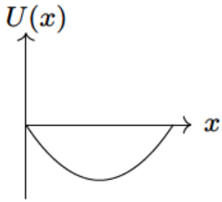
(B) 

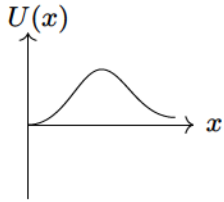
(C) 

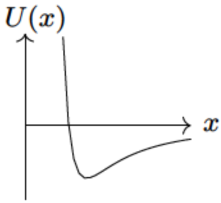
(D) 

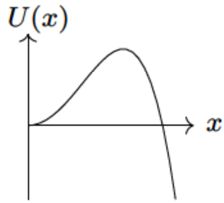
Q 4. An ideal spring with spring constant k is hung from the ceiling and a block of mass M is attached to its lower end. The mass is released with the spring initially unstretched. Then the maximum extension in the spring is
(A) $\frac{4Mg}{k}$ (B) $\frac{2Mg}{k}$ (C) $\frac{Mg}{k}$ (D) $\frac{Mg}{2k}$

Q 5. A particle, which is constrained to move along x-axis, is subjected to a force in the same direction which varies with the distance x of the particle from the origin as $F(x) = -kx + ax^3$. Here, k and a are positive constants. For $x \geq 0$, the functional form of the potential energy $U(x)$ of the particle is

(A) 

(B) 

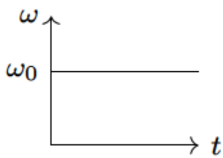
(C) 

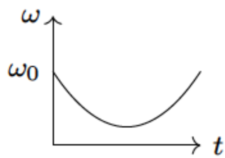
(D) 

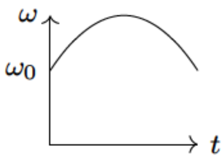
Q 6. Two blocks of masses 10 kg and 4 kg are connected by a spring of negligible mass and placed on a frictionless horizontal surface. An impulse gives a velocity of 14 m/s to the heavier block in the direction of the lighter block. The velocity of the centre of mass is

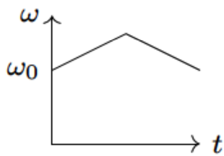
(A) 30 m/s (B) 20 m/s (C) 10 m/s (D) 5 m/s

Q 7. A circular platform is free to rotate in a horizontal plane about a vertical axis passing through its centre. A tortoise is sitting at the edge of the platform. Now the platform is given an angular velocity ω_0. When the tortoise moves along a chord of the platform with a constant velocity (with respect to the platform), the angular velocity of the platform ω will vary with time t as

(A) 

(B) 

(C) 

(D) 

Q 8. A cylinder rolls up an inclined plane, reaches some height and then rolls down (without slipping throughout these motions). The directions of the frictional force acting on the cylinder are

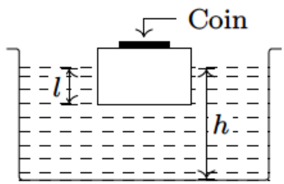
(A) up the incline while ascending and down the incline while descending.

(B) up the incline while ascending as well as descending.

(C) down the incline while ascending and up the incline while descending.

(D) down the incline while ascending as well as descending.

Q 9. A wooden block, with a coin placed on its top, floats in water as shown in the figure. The distance l and h are shown there. After some time the coin falls into the water. Then,



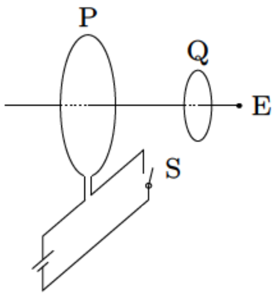
(A) l decreases and h increases.
(B) l increases and h decreases.
(C) Both l and h increase.
(D) Both l and h decrease.

Q 10. A short-circuited coil is placed in a time varying magnetic field. Electric power is dissipated due to the current induced in the coil. If the number of turns were to be quadrupled (four times) and the wire radius halved, the electrical power dissipated would be

(A) halved (B) the same

(C) doubled (D) quadrupled

Q 11. As shown in the figure, P and Q are two coaxial conducting loops separated by some distance. When the switch S is closed, a clockwise current I_{P} flows in P (as seen by E) and an induced current I_{Q_1} flows in Q. The switch remains closed for a long time. When S is opened, a current I_{Q_2} flows in Q. Then the direction of I_{Q_1} and I_{Q_2} (as seen by E) are

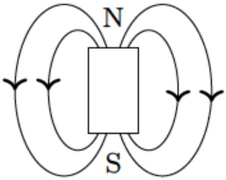


(A) respectively clockwise and anticlockwise.
(B) both clockwise.
(C) both anticlockwise.
(D) respectively anticlockwise and clockwise.

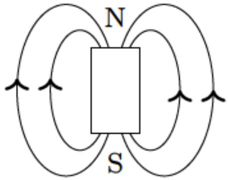
Q 12. A particle of mass m and charge q moves with a constant velocity v along the positive x direction. It enters a region containing a uniform magnetic field B directed along the negative z direction, extending from $x = a$ to $x = b$. The minimum value of v required so that the particle can just enter the region $x > b$ is
(A) $\frac{qbB}{m}$ (B) $\frac{q(b-a)B}{m}$ (C) $\frac{qaB}{m}$ (D) $\frac{q(b+a)B}{2m}$

Q 13. The magnetic field lines due to a bar magnet are correctly shown in

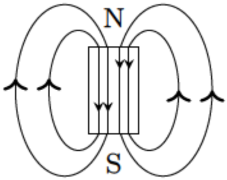
(A)



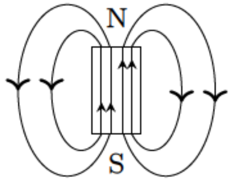
(B)



(C)



(D)



Q 14. A long straight wire along the z-axis carries a current I in the negative z direction. The magnetic field vector $\vec{B}$ at a point having coordinate (x, y) on the $z = 0$ plane is

(A) $\frac{\mu_0 I(y\hat{\imath}-x\hat{\jmath})}{2\pi(x^2+y^2)}$ (B) $\frac{\mu_0 I(x\hat{\imath}+y\hat{\jmath})}{2\pi(x^2+y^2)}$

(C) $\frac{\mu_0 I(x\hat{\jmath}-y\hat{\imath})}{2\pi(x^2+y^2)}$ (D) $\frac{\mu_0 I(x\hat{\imath}-y\hat{\jmath})}{2\pi(x^2+y^2)}$

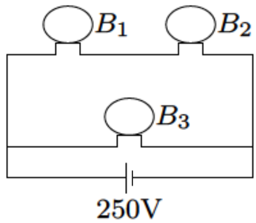
Q 15. Two identical capacitors have the same capacitance C. One of them is charged to potential V_1 and the other to V_2. The negative ends of the capacitors are connected together. When the positive ends are also connected, the decrease in energy of the combined system is

(A) $\frac{1}{4}C\left(V_1^2 - V_2^2\right)$ (B) $\frac{1}{4}C\left(V_1^2 + V_2^2\right)$

(C) $\frac{1}{4}C\left(V_1 - V_2\right)^2$ (D) $\frac{1}{4}C\left(V_1 + V_2\right)^2$

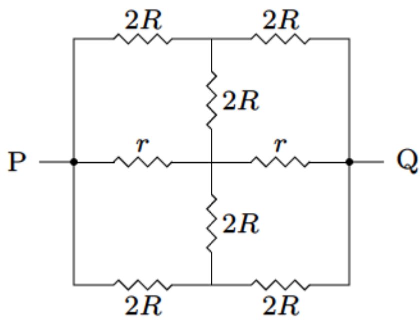
Q 16. The potential difference applied to an X-ray tube is 5 kV and the current through it is 3.2 mA. Then the number of electrons striking the target per second is
(A) 2×10^{16} (B) 5×10^{6} (C) 1×10^{17} (D) 4×10^{15}

Q 17. A 100 W bulb B_1 and two 60 W bulbs B_2 and B_3, are connected to a 250 V source, as shown in the figure. Now W_1, W_2 and W_3 are the output powers of the bulb B_1, B_2 and B_3 respectively. Then,



(A) $W_1 > W_2 = W_3$ (B) $W_1 > W_2 > W_3$
(C) $W_1 < W_2 = W_3$ (D) $W_1 < W_2 < W_3$

Q 18. The effective resistance between points P and Q of the electrical circuit shown in the figure is

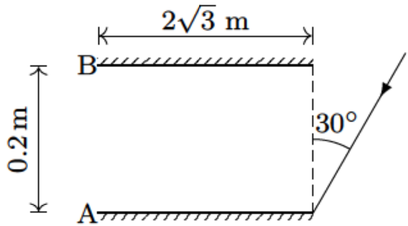


(A) $\frac{2Rr}{R+r}$ (B) $\frac{8R(R+r)}{3R+r}$ (C) $2r + 4R$ (D) $\frac{5R}{2} + 2r$

Q 19. A sonometer wire resonates with a given tuning fork forming standing waves with five antinodes between the two bridges when a mass of 9 kg is suspended from the wire. When this mass is replaced by mass M, the wire resonates with the same tuning fork forming three antinodes for the same positions of the bridges. The value of M is
(A) 25 kg (B) 5 kg (C) 12.5 kg (D) 1/25 kg

Q 20. A siren placed at a railway platform is emitting sound of frequency 5 kHz. A passenger sitting in a moving train A records a frequency of 5.5 kHz, while the train approaches the siren. During his return journey in a different train B he records a frequency of 6.0 kHz while approaching the same siren. The ratio of the velocity of train B to that of train A is
(A) 242/252 (B) 2 (C) 5/6 (D) 11/6

Q 21. Two plane mirrors A and B are aligned parallel to each other, as shown in the figure. A light ray is incident at an angle 30° at a point just inside one end of A. The plane of incidence coincides with the plane of the figure. The maximum number of times the ray undergoes reflections (including the first one) before it emerges out is

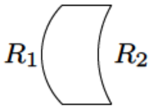


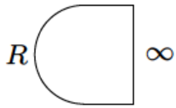
(A) 28 (B) 30 (C) 32 (D) 34

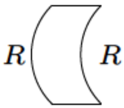
Q 22. In the ideal double-slit experiment, when a glass-plate (refractive index 1.5) of thickness t is introduced in the path of one of the interfering beams (wavelength λ), the intensity at the position where the central maximum occurred previously remains unchanged. The minimum thickness of the glass-plate is

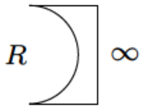
(A) 2λ (B) $2\lambda/3$ (C) $\lambda/3$ (D) λ

Q 23. Which of the following spherical lenses does not exhibit dispersion? The radii of curvature of the surfaces of the lenses are as given in the diagrams,

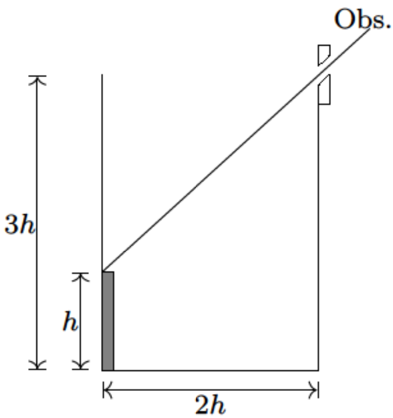
(A)


(B)


(C)


(D)


Q 24. An observer can see through a pin-hole at the top end of a thin rod of height h, placed as shown in the figure. The beaker height is $3h$ and its radius is h. When the beaker is filled with a liquid up to a height $2h$, he can see the lower end of the rod. Then the refractive index of the liquid is



(A) $\frac{5}{2}$ (B) $\sqrt{\frac{5}{2}}$ (C) $\sqrt{\frac{3}{2}}$ (D) $\frac{3}{2}$

Q 25. An ideal black-body at room temperature is thrown into a furnace. It is observed that,

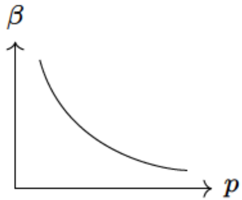
(A) initially it is the darkest body and at later times the brightest.

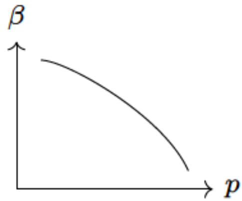
(B) it is the darkest body at all times.

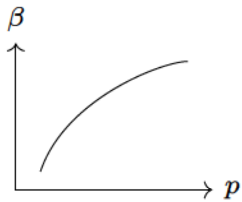
(C) it cannot be distinguished at all times.

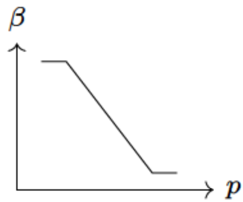
(D) initially it is the darkest body and at later times it cannot be distinguished.

Q 26. Which of the following graphs correctly represent the variation of $\beta = -\frac{1}{V}\frac{\mathrm{d}V}{\mathrm{d}p}$ with p for an ideal gas at constant temperature?

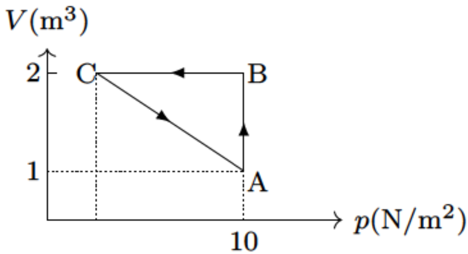
(A) 

(B) 

(C) 

(D) 

Q 27. An ideal gas is taken through the cycle ABCA, as shown in the figure. If the net heat supplied to the gas in the cycle is 5 J, the work done by the gas in the process $C \rightarrow A$ is



(A) -5 J (B) -10 J (C) -15 J (D) -20 J

Q 28. Which of the following processes represent a γ-decay?
(A) ${}^{A}X_{Z} + \gamma \rightarrow {}^{A}X_{Z\text{-}1} + a + b$
(B) ${}^{A}X_{Z} + {}^{1}n_{0} \rightarrow {}^{A\text{-}3}X_{Z\text{-}2} + c$
(C) ${}^{A}X_{Z} \rightarrow {}^{A}X_{Z} + f$
(D) ${}^{A}X_{Z} + e_{-1} \rightarrow {}^{A}X_{A\text{-}1} + g$

Q 29. The half-life of ^{215}At is 100 μs. The time taken for the activity of a sample of ^{215}At to decay to $\frac{1}{16}$th of its initial value is

(A) 400 μs (B) 63 μs (C) 40 μs (D) 300 μs

Q 30. A hydrogen atom and a Li^{2+} ion are both in the second excited state. If l_{H} and l_{Li} are their respective electronic angular momentum, and E_{H} and E_{Li} their respective energies, then,

(A) $l_{\mathrm{H}} > l_{\mathrm{Li}}$ and $|E_{\mathrm{H}}| > |E_{\mathrm{Li}}|$
(B) $l_{\mathrm{H}} = l_{\mathrm{Li}}$ and $|E_{\mathrm{H}}| < |E_{\mathrm{Li}}|$
(C) $l_{\mathrm{H}} = l_{\mathrm{Li}}$ and $|E_{\mathrm{H}}| > |E_{\mathrm{Li}}|$
(D) $l_{\mathrm{H}} < l_{\mathrm{Li}}$ and $|E_{\mathrm{H}}| < |E_{\mathrm{Li}}|$

Answers

1. B
2. C
3. C
4. B
5. D
6. C
7. C
8. B
9. D
10. B
11. D
12. B
13. D
14. A
15. C
16. A
17. D
18. A
19. A
20. B
21. B
22. A
23. C
24. B
25. A
26. A
27. A
28. C
29. A
30. B

Main Paper

The main paper in physics has 12 descriptive questions.

Descriptive

There are 12 questions in total. Solve all of them.

Q 1. A hydrogen-like atom (described by the Bohr model) is observed to emit six wavelengths, originating from all possible transitions between a group of levels. These levels have energies between -0.85 eV and -0.544 eV (including both these values). [Take $hc = 1240$ eV-nm, ground state energy of hydrogen atom $= -13.6$ eV.]

(a) Find the atomic number of the atom.

(b) Calculate the smallest wavelength emitted in these transitions.

Q 2. Two metallic plates A and B each of area 5×10^{-4} m^2, are placed parallel to each other at separation of 1 cm. Plate B carries a positive charge of 33.7×10^{-12} C. A monochromatic beam of light, with photons of energy 5 eV each, starts falling on plate A at $t = 0$ so that 10^{16} photons fall on it per square metre per second. Assume that one photoelectron is emitted for every 10^6 incident photons. Also assume that all the emitted photoelectrons are collected by plate B and the work function of plate A remains constant at the value of 2 eV. Determine,

(a) the number of photoelectrons emitted up to $t = 10$ s.

(b) the magnitude of the electric field between the plates A and B at $t = 10$ s.

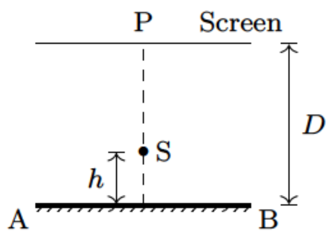
(c) The kinetic energy of the most energetic photoelectrons emitted at $t = 10$ s when it reaches plate B.

[Neglect time taken by the photoelectron to reach plate B. Take $\epsilon_0 = 8.85 \times 10^{-12}$ C^2/N-m^2]

Q 3. A cubical box of side 1 m contains helium gas (atomic weight 4) at a pressure of 100 $\mathrm{N/m^2}$. During an observation time of 1 s, an atom travelling with the *rms* speed parallel to one of the edges of the cube, was found to make 500 hits with a particular wall, without any collision with other atoms. Take, $R = \frac{25}{3}$ J/mol K and $k = 1.38 \times 10^{-23}$ J/K.

(a) Evaluate the temperature of the gas.
(b) Evaluate the average kinetic energy per atom.
(c) Evaluate the total mass of helium gas in the box.

Q 4. A point source S emitting light of wavelength 600 nm is placed at a very small height h above a flat reflecting surface AB (see figure). The intensity of the reflected light is 36% of the incident intensity. Interference fringes are observed on a screen placed parallel to the reflecting surface at a very large distance D from it.



(a) What is the shape of the interference fringes on the screen?

(b) Calculate the ratio of the minimum to the maximum intensities in the interference fringes formed near the point P (shown in the figure).

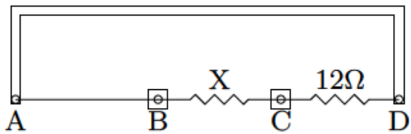
(c) If the intensity at point P corresponds to a maximum, calculate the minimum distance through which the reflecting surface AB should be shifted so that the intensity at P again becomes maximum.

Q 5. Two narrow cylindrical pipes A and B have the same length. Pipe A is open at both ends and is filled with a monatomic gas of molar mass M_A. Pipe B is open at one end and closed at the other end, and is filled with a diatomic gas of molar mass M_B. Both gases are at the same temperature.

(a) If the frequency of the second harmonic of pipe A is equal to the frequency of the third harmonic of the fundamental mode in pipe B, determine the value of M_A/M_B.

(b) Now the open end of the pipe B is closed (so that the pipe is closed at both ends). Find the ratio of the fundamental frequency in pipe A to that in pipe B.

Q 6. A thin uniform wire AB of length 1 m, an unknown resistance X and a resistance of 12 Ω are connected by thick conducting strips, as shown in the figure. A battery and galvanometer (with a sliding jockey connected to it) are also available. Connections are to be made to measure the unknown resistance X using the principle of Wheatstone bridge. Answer the following questions.

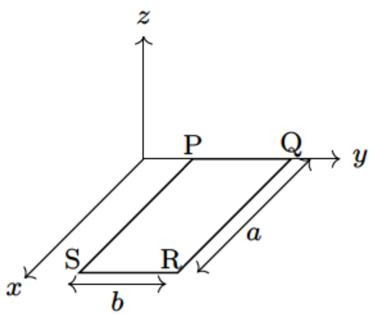


(a) Are there positive and negative terminals on the galvanometer?

(b) Copy the figure in your answer book and show the battery and the galvanometer (with jockey) connected at appropriate points.

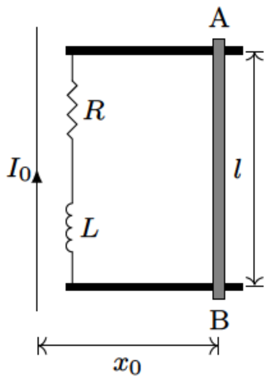
(c) After appropriate connections are made, it is found that no deflection takes place in the galvanometer when the sliding jockey touches the wire at a distance of 60 cm from A. Obtain the value of the resistance X.

Q 7. A rectangular loop PQRS made from a uniform wire has length a, width b and mass m. It is free to rotate about the arm PQ, which remains hinged along a horizontal line taken as the y-axis (see figure). Take the vertically upward direction as the z-axis. A uniform magnetic field $\vec{B} = B_0(3\hat{\imath}+4\hat{k})$ exists in the region. The loop is held in the x-y plane and a current I is passed through it. The loop is now released and is found to stay in the horizontal position in equilibrium.



(a) What is the direction of the current I in PQ?
(b) Find the magnetic force on the arm RS.
(c) Find the expression for I in terms of B_0, a, b and m.

Q 8. A metal bar AB can slide on two parallel thick metallic rails separated by a distance l. A resistance R and an inductance L are connected to the rails as shown in the figure. A long straight wire, carrying a constant current I_0 is placed in the plane of the rails as shown. The bar AB is held at rest at a distance x_0 from the long wire. At $t = 0$, it is made to slide on the rails away from the wire. Answer the following questions,

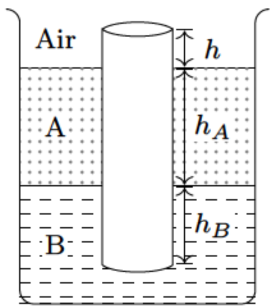


(a) Find the relation among i, $\frac{\mathrm{d}i}{\mathrm{d}t}$ and $\frac{\mathrm{d}\phi}{\mathrm{d}t}$, where i is the current in the circuit and ϕ is the flux of the magnetic field due to the long wire through the circuit.

(b) It is observed that at time $t = T$, the metal bar AB is at a distance of $2x_0$ from the long wire and the resistance R carries a current i_1. Obtain an expression for the net charge that has flown through resistance R from $t = 0$ to $t = T$.

(c) The bar is suddenly stopped at time T. The current through resistance R is found $i_1/4$ at time $2T$. Find the value of L/R in terms of the other given quantities.

Q 9. A uniform solid cylinder of density $0.8\,\mathrm{g/cm^3}$ floats in equilibrium in a combination of two non-mixing liquids A and B with its axis vertical. The densities of the liquids A and B are $0.7\,\mathrm{g/cm^3}$ and $1.2\,\mathrm{g/cm^3}$, respectively. The height of liquid A is $h_A = 1.2$ cm. The length of the part of the cylinder immersed in liquid B is $h_B = 0.8$ cm.

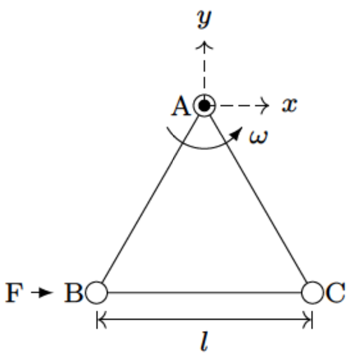


(a) Find the total force exerted by liquid A on the cylinder.

(b) Find h, the length of the part of the cylinder in air.

(c) The cylinder is depressed in such a way that its top surface is just below the upper surface of liquid A and is then released. Find the acceleration of the cylinder immediately after it is released.

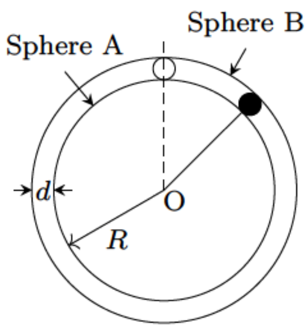
Q 10. Three particles A, B and C, each of mass m, are connected to each other by three massless rigid rods to form a rigid equilateral triangular body of side l. This body is placed on a horizontal frictionless table (x-y plane) and is hinged to it at the point A, so that it can move without friction about the vertical axis through A (see figure). The body is set into rotational motion on the table about A with a constant angular velocity ω.



(a) Find the magnitude of the horizontal force exerted by the hinge on the body.

(b) at time T, when the side BC is parallel to the x-axis, a force F is applied on B along BC (as shown). Obtain the x-component and the y-component of the force exerted by the hinge on the body, immediately after time T.

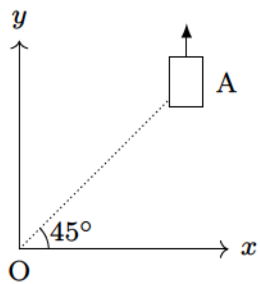
Q 11. A spherical ball of mass m is kept at the highest point in the space between two fixed, concentric spheres A and B (see figure). The smaller sphere A has a radius R and the space between the two spheres has a width d. The ball has a diameter very slightly less than d. All surfaces are frictionless. The ball is given a gentle push (towards the right in the figure). The angle made by the radius vector of the ball with the upward vertical is denoted by θ.



(a) Express the total normal reaction force exerted by the sphere on the ball as a function of angle θ.

(b) Let N_A and N_B denote the magnitudes of the normal reaction forces on the ball exerted by the spheres A and B, respectively. Sketch the variations of N_A and N_B as function of $\cos\theta$ in the range $0 \leq \theta \leq \pi$ by drawing two separate graphs in your answer book, taking $\cos\theta$ on the horizontal axis.

Q 12. On a frictionless horizontal surface, assumed to be x-y plane, a small trolley A is moving along a straight line parallel to the y-axis (see figure) with a constant velocity of $\left(\sqrt{3}-1\right)$ m/s. At a particular instant when the line OA makes an angle of 45° with the x-axis, a ball is thrown along the surface from the origin O. Its velocity makes an angle ϕ with the x-axis and it hits the trolley.



(a) The motion of the ball is observed from the frame of the trolley. Calculate the angle θ made by the velocity vector of the ball with the x-axis in this frame.

(b) Find the speed of the ball with respect to the surface, if $\phi = 4\theta/3$.

Answers

1. (a) 3 (b) 4052 nm

2. (a) 5×10^7 (b) 2×10^3 N/C (c) 23 eV

3. (a) 160 K (b) 3.312×10^{-21} J (c) 0.3 g

4. (a) circular (b) 1/16 (c) 300 nm

5. (a) $\frac{400}{189}$ (b) $\frac{3}{4}$

6. (a) No (b) See solution (c) 8 Ω

7. (a) P to Q (b) $IbB_0(3\hat{k} - 4\hat{\imath})$ (c) $\frac{mg}{6bB_0}$

8. (a) $\frac{\mathrm{d}\phi}{\mathrm{d}t} = iR + L\frac{\mathrm{d}i}{\mathrm{d}t}$ (b) $\frac{1}{R}\left[\frac{\mu_0 I_0 l}{2\pi}\ln 2 - Li_1\right]$ (c) $\frac{T}{\ln 4}$

9. (a) zero (b) 0.25 cm (c) $g/6$

10. (a) $\sqrt{3}ml\omega^2$ (b) $F_x = -\frac{F}{4}$, $F_y = \sqrt{3}ml\omega^2$

11. (a) $mg(3\cos\theta - 2)$ (b) for $\theta \le \cos^{-1}\frac{2}{3}$, $N_A = mg(3\cos\theta - 2), N_B = 0$ and, for $\theta \ge \cos^{-1}\frac{2}{3}$, $N_A = 0, N_B = mg(2 - 3\cos\theta)$

12. (a) 45° (b) 2 m/s

IIT JEE 2001

IIT JEE 2001 has a screening paper and a main paper.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Screening Paper

The physics part of screening paper has 35 objective questions of the single option correct type.

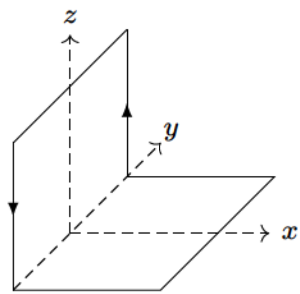
One Option Correct

Each question has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. A particle executes SHM between $x = -A$ and $x = +A$. The time taken for it to go from 0 to $A/2$ is T_1 and to go from $A/2$ to A is T_2, then,
(A) $T_1 < T_2$ (B) $T_1 > T_2$ (C) $T_1 = T_2$ (D) $T_1 = 2T_2$

Q 2. A uniform electric field pointing in positive x direction exists in a region. Let A be the origin, B be the point on the x-axis at $x = +1$ cm, and C be the point on the y-axis at $y = +1$ cm. Then the potentials at the points A, B and C satisfy
(A) $V_A < V_B$ (B) $V_A > V_B$
(C) $V_A < V_C$ (D) $V_A > V_C$

Q 3. A non-planar loop of conducting wire carrying a current I is placed as shown in the figure. Each of the straight sections of the loop is of length $2a$. The magnetic field due to this loop at the point $P(a, 0, a)$ points in the direction

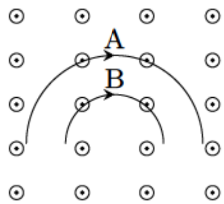


(A) $\frac{1}{\sqrt{2}}[-\hat{\jmath}+\hat{k}]$ (B) $\frac{1}{\sqrt{3}}[-\hat{\jmath}+\hat{k}+\hat{\imath}]$
(C) $\frac{1}{\sqrt{3}}[\hat{\imath}+\hat{\jmath}+\hat{k}]$ (D) $\frac{1}{\sqrt{2}}[\hat{\imath}+\hat{k}]$

Q 4. A coil having N turns is wound tightly in the form of a spiral with inner and outer radii a and b respectively. When a current I passes through the coil, the magnetic field at the centre is

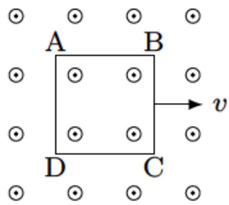
(A) $\frac{\mu_0 NI}{b}$ (B) $\frac{2\mu_0 NI}{a}$ (C) $\frac{\mu_0 NI}{2(b-a)} \ln \frac{b}{a}$ (D) $\frac{\mu_0 I^N}{2(b-a)} \ln \frac{b}{a}$

Q 5. Two particles A and B of masses m_A and m_B respectively and having the same charge are moving in a plane. A uniform magnetic field exists perpendicular to this plane. The speeds of the particles are v_A and v_B respectively and the trajectories are as shown in the figure. Then,



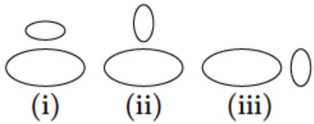
(A) $m_A v_A < m_B v_B$
(B) $m_A v_A > m_B v_B$
(C) $m_A < m_B$ and $v_A < v_B$
(D) $m_A = m_B$ and $v_A = v_B$

Q 6. A metallic square loop ABCD is moving in its own plane with velocity v in a uniform magnetic field perpendicular to its plane as shown in the figure. Electric field is induced



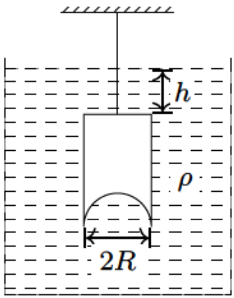
(A) in AD, but not in BC
(B) in BC, but not in AD
(C) neither in AD nor in BC
(D) in both AD and BC

Q 7. Two circular coils can be arranged in any of the three situations shown in the figure. Their mutual inductance will be



(A) maximum is situation (i).
(B) maximum is situation (ii).
(C) maximum is situation (iii).
(D) the same in all situations.

Q 8. A hemispherical portion of radius R is removed from the bottom of a cylinder of radius R. The volume of the remaining cylinder is V and mass M. It is suspended by a string in a liquid of density ρ, where it stays vertical. The upper surface of the cylinder is at a depth h below the liquid surface. The force on the bottom of the cylinder by the liquid is

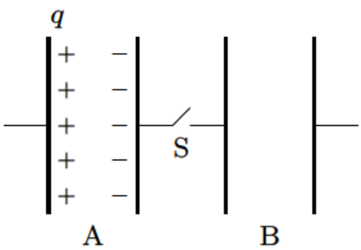


(A) Mg (B) $Mg - V\rho g$
(C) $Mg + \pi R^2 h\rho g$ (D) $\rho g(V + \pi R^2 h)$

Q 9. When a block of iron floats in mercury at 0 °C, fraction k_1 of its volume is submerged, while at the temperature 60 °C, a fraction k_2 is seen to be submerged. If the coefficient of volume expansion of iron is γ_{Fe} and that of mercury is γ_{Hg}, then the ratio k_1/k_2 can be expressed as

(A) $\frac{1+60\gamma_{\mathrm{Fe}}}{1+60\gamma_{\mathrm{Hg}}}$ (B) $\frac{1-60\gamma_{\mathrm{Fe}}}{1+60\gamma_{\mathrm{Hg}}}$ (C) $\frac{1+60\gamma_{\mathrm{Fe}}}{1-60\gamma_{\mathrm{Hg}}}$ (D) $\frac{1+60\gamma_{\mathrm{Hg}}}{1+60\gamma_{\mathrm{Fe}}}$

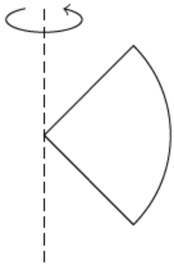
Q 10. Consider the situation shown in the figure. The capacitor A has a charge q on it whereas B is uncharged. The charge appearing on the capacitor B a long time after the switch is closed is



(A) zero (B) $q/2$ (C) q (D) $2q$

Q 11. A simple pendulum has a time period T_1 when on the earth's surface and T_2 when taken to a height R above the earth's surface, where R is the radius of the earth. The value of T_2/T_1 is
(A) 1 (B) $\sqrt{2}$ (C) 4 (D) 2

Q 12. One quarter section is cut from a uniform circular disc of radius R. This section has a mass M. It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertia about the axis of rotation is



(A) $\frac{1}{2}MR^2$ (B) $\frac{1}{4}MR^2$ (C) $\frac{1}{8}MR^2$ (D) $\sqrt{2}MR^2$

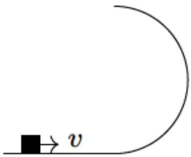
Q 13. Two particles of masses m_1 and m_2 in projectile motion have velocities $\vec{v}_1$ and $\vec{v}_2$ respectively at time $t = 0$. They collide at time t_0. Their velocities become $\vec{v}_1'$ and $\vec{v}_2'$ at time $2t_0$ while still moving in air. The value of $|(m_1\vec{v}_1' + m_2\vec{v}_2') - (m_1\vec{v}_1 + m_2\vec{v}_2)|$ is

(A) zero (B) $(m_1 + m_2)gt_0$

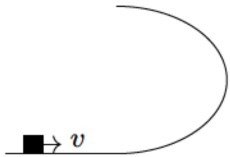
(C) $2(m_1 + m_2)gt_0$ (D) $\frac{1}{2}(m_1 + m_2)gt_0$

Q 14. A small block is shot into each of the four tracks as shown below. Each of the tracks rises to the same height. The speed with which the block enters the track is the same in all cases. At the highest point of the track, the normal reaction is maximum in

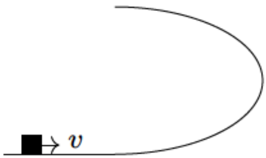
(A)



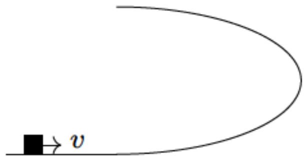
(B)



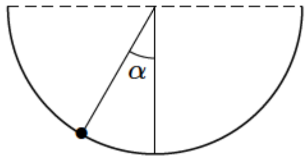
(C)



(D)

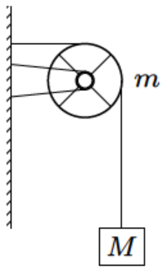


Q 15. An insect crawls up a hemispherical surface very slowly (see figure). The coefficient of friction between the surface and the insect is 1/3. If the line joining the centre of the hemispherical surface to the insect makes an angle α with the vertical, the maximum possible value of α is given by



(A) $\cot\alpha = 3$ (B) $\tan\alpha = 3$
(C) $\sec\alpha = 3$ (D) $\operatorname{cosec}\alpha = 3$

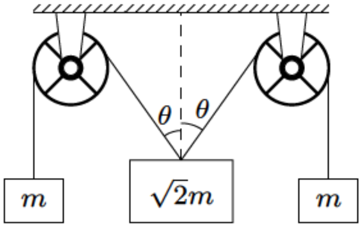
Q 16. A string of negligible mass going over a clamped pulley of mass m supports a block of mass M as shown in the figure. The force on the pulley by the clamp is given by



(A) $\sqrt{2}Mg$ (B) $\sqrt{2}mg$

(C) $\sqrt{(M+m)^2+m^2}\ g$ (D) $\sqrt{(M+m)^2+M^2}\ g$

Q 17. The pulleys and strings shown in the figure are smooth and of negligible mass. For the system to remain in equilibrium, the angle θ should be

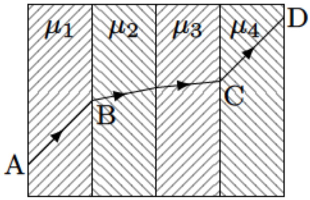


(A) $0°$ (B) $30°$ (C) $45°$ (D) $60°$

Q 18. A quantity X is given by $\epsilon_0 L \frac{\Delta V}{\Delta t}$, where ϵ_0 is the permittivity of free space, L is a length, ΔV is a potential difference and Δt is a time interval. The dimensional formula for X is the same as that of

(A) resistance (B) charge (C) voltage (D) current

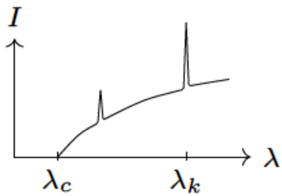
Q 19. A ray of light passes through four transparent media with refractive index μ_1, μ_2, μ_3 and μ_4 as shown in the figure. The surfaces of all media are parallel. If the emergent ray CD is parallel to the incident ray AB, we must have



(A) $\mu_1 = \mu_2$ (B) $\mu_2 = \mu_3$ (C) $\mu_3 = \mu_4$ (D) $\mu_4 = \mu_1$

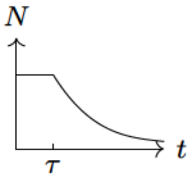
Q 20. The transition from the state $n = 4$ to $n = 3$ in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition
(A) $2 \to 1$ (B) $3 \to 2$ (C) $4 \to 2$ (D) $5 \to 4$

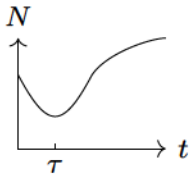
Q 21. The intensity of X-rays from a Coolidge tube is plotted against wavelength λ as shown in the figure. The minimum wavelength found is λ_c and the wavelength of the K_α line is λ_k. As the accelerating voltage is increased,

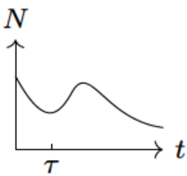


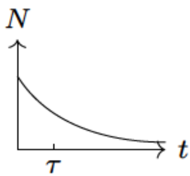
(A) $(\lambda_k - \lambda_c)$ increases. (B) $(\lambda_k - \lambda_c)$ decreases.
(C) λ_k increases. (D) λ_k decreases.

Q 22. A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life of one species is τ and that of the other is 5τ. The decay products in both cases are stable. A plot is made of the total number of radioactive nuclei as a function of time. Which of the following figure best represents the form of this plot?

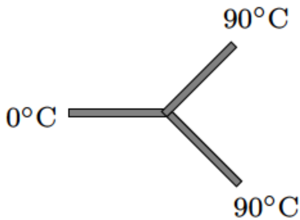
(A) 

(B) 

(C) 

(D) 

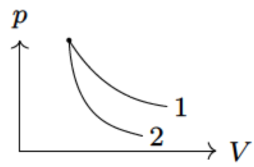
Q 23. Three rods made of the same material and having the same cross-section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0 °C and 90 °C respectively. The temperature of junction of the three rods will be



(A) 45 °C (B) 60 °C (C) 30 °C (D) 20 °C

Q 24. In a given process on an ideal gas, $\mathrm{d}W = 0$ and $\mathrm{d}Q < 0$. Then for the gas,
(A) the temperature will decrease.
(B) the volume will increase.
(C) the pressure will remain constant.
(D) the temperature will increase.

Q 25. p-V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond respectively to



(A) He and O_2 (B) O_2 and He
(C) He and Ar (D) O_2 and N_2

Q 26. Two beams of light having intensities I and $4I$ interfere to produce a fringe pattern on a screen. The phase difference between the beams is $\pi/2$ at point A and π at point B. Then the difference between resultant intensities at A and B is
(A) $2I$ (B) $4I$ (C) $5I$ (D) $7I$

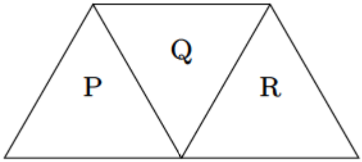
Q 27. In a Young's double slit experiment, 12 fringes are observed to be formed in a certain segment of the screen when light of wavelength 600 nm is used. If the wavelength of the light is changed to 400 nm, number of fringes observed in the same segment of the screen is given by

(A) 12 (B) 18 (C) 24 (D) 30

Q 28. The electron emitted in beta radiation originates from

(A) inner orbits of atom.
(B) free electrons existing in nuclei.
(C) decay of a neutron in a nucleus.
(D) photon escaping from the nucleus.

Q 29. A given ray of light suffers minimum deviation in an equilateral prism P. Additional prisms Q and R of identical shape and of the same material as P are now added as shown in the figure. The ray will suffer



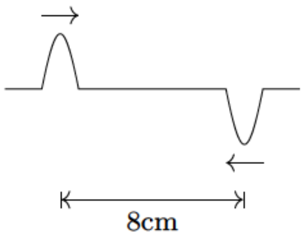
(A) greater deviation.
(B) no deviation.
(C) same deviation as before.
(D) total internal reflection.

Q 30. The ends of a stretched wire of length L are fixed at $x = 0$ and $x = L$. In one experiment the displacement of the wire is $y_1 = A\sin(\pi x/L)\sin\omega t$ and energy is E_1 and in other experiment its displacement is $y_2 = A\sin\left(2\pi x/L\right)\sin 2\omega t$ and energy is E_2. Then,

(A) $E_2 = E_1$ (B) $E_2 = 2E_1$

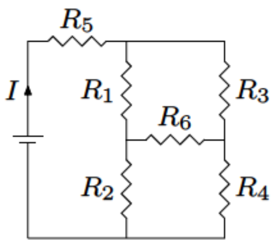
(C) $E_2 = 4E_1$ (D) $E_2 = 16E_1$

Q 31. Two pulses in a stretched string, whose centres are initially 8 cm apart, are moving towards each other as shown in the figure. The speed of each pulse is 2 cm/s. After 2 s the total energy of the pulses will be



(A) zero.
(B) purely kinetic.
(C) purely potential.
(D) partly kinetic and partly potential.

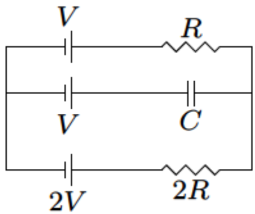
Q 32. In the given circuit, it is observed that the current I is independent of the value of the resistance R_6. Then the resistance values must satisfy



(A) $R_1 R_2 R_5 = R_3 R_4 R_6$
(B) $\frac{1}{R_5} + \frac{1}{R_6} = \frac{1}{R_1+R_2} + \frac{1}{R_3+R_4}$
(C) $R_1 R_4 = R_2 R_3$
(D) $R_1 R_3 = R_2 R_4$

Q 33. A wire of length L and three identical cells of negligible internal resistances are connected in series. Due to the current, the temperature of the wire is raised by ΔT in time t. A number N of similar cells is now connected in series with a wire of the same material and cross-section but of length $2L$. The temperature of the wire is raised by the same amount ΔT in the same time. The value of N is
(A) 4 (B) 6 (C) 8 (D) 9

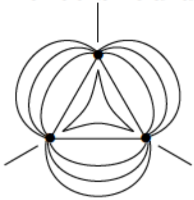
Q 34. In the given circuit, with steady current, the potential difference across the capacitor must be



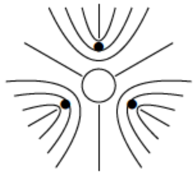
(A) V (B) $V/2$ (C) $V/3$ (D) $2V/3$

Q 35. Three positive charges of equal value q are placed at the vertices of an equilateral triangle. The resulting lines of force should be sketched as in

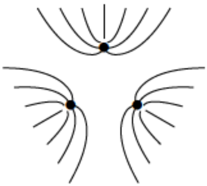
(A)



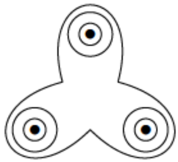
(B)



(C)



(D)



Answers

1. A
2. B
3. D
4. C
5. B
6. D
7. A
8. D
9. A
10. A
11. D
12. A
13. C
14. A
15. A
16. D
17. C
18. D
19. D
20. D
21. A
22. D
23. B
24. A
25. B
26. B
27. B
28. C
29. C
30. C
31. B
32. C
33. B
34. C
35. C

Main Paper

The main paper in physics is of 2 hour duration. It has 15 questions of total marks 100.

Descriptive

There are 15 questions in total. Solve all of them.

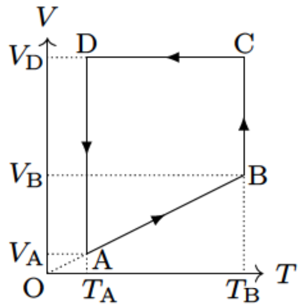
Q 1. In a nuclear reactor ^{235}U undergoes fission liberating 200 MeV of energy. The reactor has a 10% efficiency and produces 1000 MW power. If the reactor is to function for 10 years, find the total mass of uranium required.

Q 2. A nucleus at rest undergoes a decay emitting an α-particle of de-Broglie wavelength, $\lambda = 5.76 \times 10^{-15}$ m. If the mass of the daughter nucleus is 223.610 u and that of the α-particle is 4.002 u, determine the total kinetic energy in the final state. Hence obtain the mass of the parent nucleus in u. [1 u = 931.470 MeV/c^2.]

Q 3. A radioactive nucleus X decays to a nucleus Y with a decay constant $\lambda_x = 0.1\,\mathrm{s}^{-1}$, Y further decays to a stable nucleus Z with a decay constant $\lambda_y = 1/30\,\mathrm{s}^{-1}$. Initially, there are only X nuclei and their number is $N_0 = 10^{20}$. Set up the rate equations for the populations of X, Y and Z. The population of Y nucleus as a function of time is given by $N_y(t) = \frac{N_0\lambda_x}{\lambda_x-\lambda_y}\left[\exp(-\lambda_y t) - \exp(-\lambda_x t)\right]$. Find the time at which N_y is maximum and determine the populations of X and Z at that instant.

Q 4. An ice cube of mass 0.1 kg at 0 °C is placed in an isolated container which is at 227 °C. The specific heat S of the container varies with temperature T according to the empirical relation $S = A + BT$, where $A = 100\,\text{cal/(kg K)}$ and $B = 2 \times 10^{-2}\,\text{cal/(kg K}^2)$. If the final temperature of the container is 27 °C, determine the mass of the container. [Latent heat of fusion for water $= 8 \times 10^4$ cal/kg, specific heat of water $= 10^3$ cal/(kg K).]

Q 5. A monatomic ideal gas of two moles is taken through a cyclic process starting from A as shown in the figure. The volume ratio are $V_B/V_A = 2$ and $V_D/V_A = 4$. If the temperature T_A at A is 27 °C, calculate, [Give answer in terms of the gas constant R.]



(a) the temperature of the gas at point B.
(b) heat absorbed or released by the gas in each process.
(c) the total work done by the gas during the complete cycle.

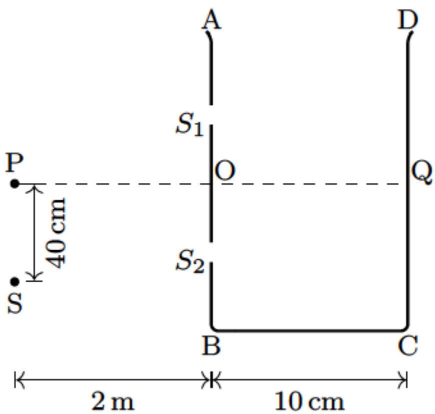
Q 6. A 5 m long cylindrical steel wire with radius 2×10^{-3} m is suspended vertically from a rigid support and carries a bob of mass 100 kg at the other end. If the bob gets snapped, calculate the change in temperature of the wire ignoring losses. [For the steel wire: Young's modulus $= 2.1 \times 10^{11}$ Pa, density $= 7860\ \mathrm{kg/m^3}$, specific heat $= 420$ J/kg K.]

Q 7. The refractive indices of the crown glass for blue and red light are 1.51 and 1.49 respectively and those of the flint glass are 1.77 and 1.73 respectively. An isosceles prism of angle $6°$ is made of crown glass. A beam of white light is incident at a small angle on this prism. The other flint glass isosceles prism is combined with the crown glass prism such that there is no deviation of the incident light.

(a) Determine the angle of the flint glass prism.

(b) Calculate the net dispersion of the combined system.

Q 8. A vessel ABCD of 10 cm width has two small slits S_1 and S_2 sealed with identical glass plates of equal thickness. The distance between the slits is 0.8 mm. POQ is the line perpendicular to the plane AB and passing through O, the middle point of S_1 and S_2. A monochromatic light source is kept at S, 40 cm below P and 2 m from the vessel, to illuminate the slits as shown in the figure. Calculate the position of the central bright fringe on the other wall CD with respect to the line OQ. Now, a liquid is poured into the vessel and filled upto OQ. The central bright fringe is found to be at Q. Calculate the refractive index of the liquid.



Q 9. A thin convex lens of refractive index 3/2 is placed on a horizontal plane mirror as shown in the figure. The space between the lens and the mirror is then filled with water of refractive index 4/3. It is found that when a point object is placed 15 cm above the lens on its principal axis, the object coincides with its own image. On repeating with another liquid, the object and the image again coincide at a distance of 25 cm from the lens. Calculate the refractive index of the liquid.

Q 10. A boat is travelling in a river with a speed of 10 m/s along the stream flowing with a speed of 2 m/s. From this boat a sound transmitter is lowered into the river through a rigid support. The wavelength of the sound emitted from the transmitter inside the water is 14.45 mm. Assume the attenuation of sound in water and air is negligible.

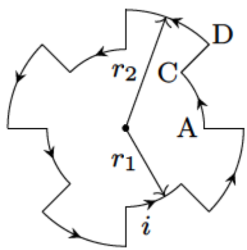
(a) What will be the frequency detected by a receiver kept inside the river downstream?

(b) The transmitter and the receiver are now pulled up into air. The air is blowing with a speed of 5 m/s in the direction opposite to the river stream. Determine the frequency of the sound detected by the receiver?

[Temperature of the air and water = 20°C, Density of river water = 10^3 kg/m^3, Bulk modulus of the water = 2.088×10^9 Pa, $R = 8.31$ J/mol K, Mean molecular mass of air = 28.8×10^{-3} kg/mol, C_p/C_V of air = 1.4.]

Q 11. A small ball of mass 2×10^{-3} kg having a charge of 1 μC is suspended by a string of length 0.8 m. Another identical ball having the same charge is kept at the point of suspension. Determine the minimum horizontal velocity which should be imparted to the lower ball, so that it can make complete revolution.

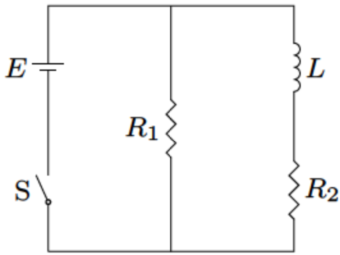
Q 12. A current of 10 A flows around a closed path in a circuit which is in the horizontal plane as shown in the figure. The circuit consists of eight alternating arcs of radii $r_1 = 0.08$ m and $r_2 = 0.12$ m. Each arc subtends same angle at the centre.



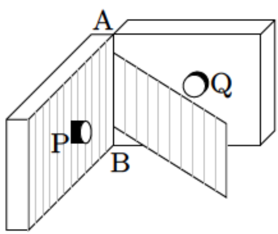
(a) Find the magnetic field produced by this circuit at the centre.

(b) An infinitely long straight wire carrying a current of 10 A is passing through the centre of the above circuit vertically with the direction of the current being into the plane of the circuit. What is the force acting on the wire at the centre due to the current in the circuit? What is the force acting on the arc AC and the straight segment CD due to the current at the centre?

Q 13. An inductor of inductance $L = 400$ mH and resistors of resistance $R_1 = 2\ \Omega$ and $R_2 = 2\ \Omega$ are connected to a battery of emf $E = 12$ V as shown in the figure. The internal resistance of the battery is negligible. The switch S is closed at time $t = 0$. What is the potential drop across L as a function of time? After the steady state is reached, the switch is opened. What is the direction and the magnitude of current through R_1 as a function of time?



Q 14. Two heavy metallic plates are joined together at 90° to each other. A laminar sheet of mass 30 kg is hinged at the line AB joining the two heavy metallic plates. The hinges are frictionless. The moment of inertia of the laminar sheet about an axis parallel to AB and passing through its centre of mass is 1.2 kg m^2. Two rubber obstacles P and Q are fixed, one on each metallic plate at a distance 0.5 m from the line AB. This distance is chosen, so that the reaction due to the hinges on the laminar sheet is zero during the impact. Initially the laminar sheet hits one of the obstacles with an angular velocity 1 rad/s and turns back. If the impulse on the sheet due to each obstacle is 6 N s,

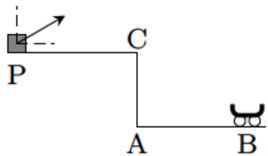


(a) Find the location of the centre of mass of the laminar sheet from AB.

(b) At what angular velocity does the laminar sheet come back after the first impact?

(c) After how many impacts, does the laminar sheet come to rest?

Q 15. A car P is moving with a uniform speed of $5\sqrt{3}$ m/s towards a carriage of mass 9 kg at rest kept on the rails at a point B as shown in the figure. The height AC is 120 m. Cannon balls of 1 kg are fired from the car with an initial velocity 100 m/s at an angle 30° with the horizontal. The first cannon ball hits the stationary carriage after a time t_0 and sticks to it. Determine t_0.



At t_0, a second cannon ball is fired. Assume that the resistive force between the rails and the carriage is constant and ignore the vertical motion of the carriage throughout. If the second ball also hits and sticks to the carriage, what will be the horizontal velocity of the carriage just after the second impact?

Answers

1. 3.84×10^4 kg
2. (a) 6.3 MeV (b) 227.618 u
3. (a) $\mathrm{d}N_x/\mathrm{d}t = -\lambda_x N_x$, $\mathrm{d}N_y/\mathrm{d}t = \lambda_x N_x - \lambda_y N_y$, $\mathrm{d}N_z/\mathrm{d}t = \lambda_y N_y$. (b) 16.48 s (c) 1.92×10^{19}, 2.32×10^{19}
4. 0.495 kg
5. (a) 600 K (b) $1500R$, $831.6R$, $-900R$, $-831.6R$ (c) $600R$
6. 4.39×10^{-3} K
7. (a) 4° (b) −0.04°
8. 2 cm above point Q on side CD, $\mu = 1.0016$
9. 1.6
10. (a) 1.0069×10^5 Hz (b) 1.0304×10^5 Hz
11. 5.86 m/s
12. (a) 6.54×10^{-5} T (b) Zero, Zero, 8.1×10^{-6} N
13. $12\mathrm{e}^{-5\mathrm{t}}$ V, $6\mathrm{e}^{-10\mathrm{t}}$ A (clockwise)
14. (a) 0.1 m (b) 1 rad/s (c) sheet will never come to rest
15. 12 s, 15.75 m/s

IIT JEE 2000

IIT JEE 2000 has a screening paper and a main paper.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Screening Paper

The physics part of screening paper has 35 objective questions of the single option correct type.

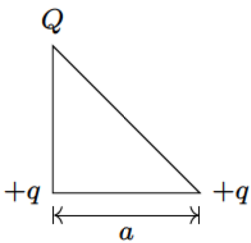
One Option Correct

Each question has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. A large open tank has two holes in the wall. One is a square hole of side L at a depth y from the top and the other is a circular hole of radius R at a depth $4y$ from the top. When the tank is completely filled with water, the quantities of water flowing out per second from both holes are the same. Then, R is equal to

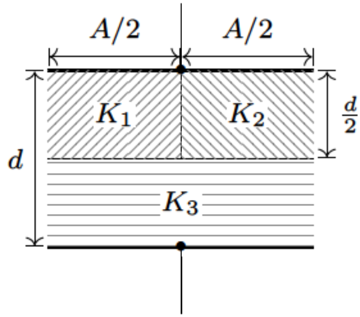
(A) $\frac{L}{\sqrt{2\pi}}$ (B) $2\pi L$ (C) L (D) $\frac{L}{2\pi}$

Q 2. Three charges Q, $+q$ and $+q$ are placed at the vertices of a right angled isosceles triangle as shown in the figure. The net electrostatic energy of the configuration is zero, if Q is equal to



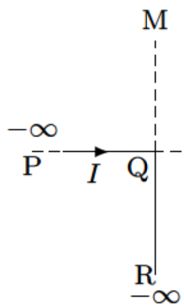
(A) $\frac{-q}{1+\sqrt{2}}$ (B) $\frac{-2q}{2+\sqrt{2}}$ (C) $-2q$ (D) $+q$

Q 3. A parallel plate capacitor of area A, plate separation d and capacitance C is filled with three different dielectric materials having dielectric constants K_1, K_2 and K_3 as shown. If a single dielectric material is to be used to have the same capacitance C in this capacitor then its dielectric constant K is given by



(A) $\frac{1}{K} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{2K_3}$
(B) $\frac{1}{K} = \frac{1}{K_1+K_2} + \frac{1}{2K_3}$
(C) $\frac{1}{K} = \frac{K_1K_2}{K_1+K_2} + 2K_3$
(D) $K = \frac{K_1K_3}{K_1+K_3} + \frac{K_2K_3}{K_2+K_3}$

Q 4. An infinitely long conductor PQR is bent to form a right angle as shown in the figure. A current I flows through PQR. The magnetic field due to this current at the point M is B_1. Now, another infinitely long straight conductor QS is connected at Q, so that current is $I/2$ in QR as well as in QS, the current in PQ remaining unchanged. The magnetic field at M is now B_2. The ratio B_1/B_2 is given by



(A) 1/2 (B) 1 (C) 2/3 (D) 2

Q 5. An ionized gas contains both positive and negative ions. If it is subjected simultaneously to an electric field along the $+x$ direction and a magnetic field along $+z$ direction, then

(A) positive ions deflect towards $+y$ direction and negative ions towards $-y$ direction.

(B) all ions deflect towards $+y$ direction.

(C) all ions deflect towards $-y$ direction.

(D) positive ions deflect towards $-y$ direction and negative ions towards $+y$ direction.

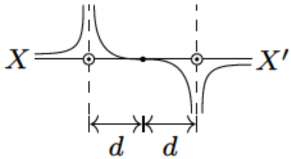
Q 6. A particle of charge q and mass m moves in a circular orbit of radius r with angular speed ω. The ratio of the magnitude of its magnetic moment to that of its angular momentum depends on

(A) ω and q (B) ω, q and m

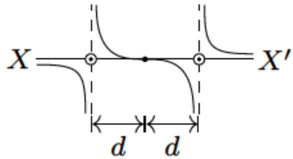
(C) q and m (D) ω and m

Q 7. Two long parallel wires are at a distance $2d$ apart. They carry steady equal currents flowing out of the plane of the paper as shown. The variation of the magnetic field B along the line XX' is given by

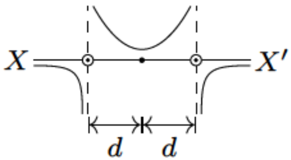
(A)



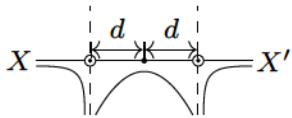
(B)



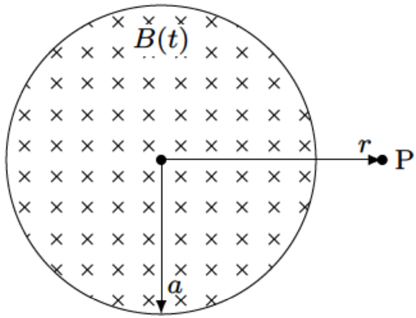
(C)



(D)



Q 8. A uniform but time-varying magnetic field $B(t)$ exists in a circular region of radius a and is directed into the plane of the paper as shown. The magnitude of the induced electric field at point P at a distance r from the centre of the circular region,



(A) is zero (B) decreases as $1/r$
(C) increases as r (D) decreases as $1/r^2$

Q 9. A coil of wire having finite inductance and resistance has a conducting ring placed co-axially within it. The coil is connected to a battery at time $t = 0$, so that a time dependent current $I_1(t)$ starts flowing through the coil. If $I_2(t)$ is the current induced in the ring and $B(t)$ is the magnetic field at the axis of the coil due to $I_1(t)$, then as a function of time $t > 0$, the product $I_2(t)B(t)$,

(A) increases with time.
(B) decreases with time.
(C) does not vary with time.
(D) passes through a maximum.

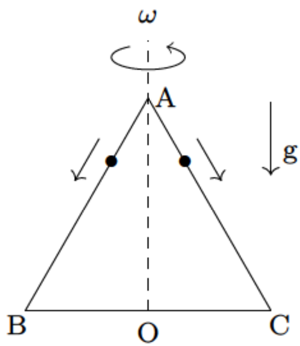
Q 10. Two vibrating strings of the same material but of lengths L and $2L$ have radii $2r$ and r respectively. They are stretched under the same tension. Both the strings vibrate in their fundamental modes, the one of length L with frequency ν_1 and the other with frequency ν_2. The ratio ν_1/ν_2 is given by
(A) 2 (B) 4 (C) 8 (D) 1

Q 11. The period of oscillation of simple pendulum of length L suspended from the roof of the vehicle which moves without friction, down an inclined plane of inclination α, is given by

(A) $2\pi\sqrt{\frac{L}{g\cos\alpha}}$ (B) $2\pi\sqrt{\frac{L}{g\sin\alpha}}$

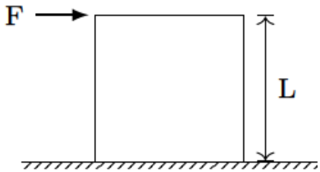
(C) $2\pi\sqrt{\frac{L}{g}}$ (D) $2\pi\sqrt{\frac{L}{g\tan\alpha}}$

Q 12. An equilateral triangle ABC formed from a uniform wire has two small identical beads initially located at A. The triangle is set rotating about the vertical axis AO. Then the beads are released from rest simultaneously and allowed to slide down, one along AB and other along AC as shown. Neglecting frictional effects, the quantities that are conserved as beads slide down are



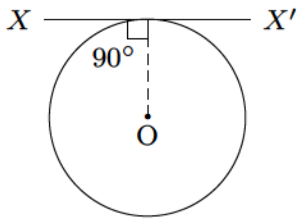
(A) angular velocity and total energy (kinetic and potential).
(B) total angular momentum and total energy.
(C) angular velocity and moment of inertia about the axis of rotation.
(D) total angular momentum and moment of inertia about the axis of rotation.

Q 13. A cubical block of side L rests on a rough horizontal surface with coefficient of friction μ. A horizontal force F is applied on the block as shown. If the coefficient of friction is sufficiently high, so that the block does not slide before toppling, the minimum force required to topple the block is



(A) infinitesimal (B) $mg/4$
(C) $mg/2$ (D) $mg(1-\mu)$

Q 14. A thin wire of length L and uniform linear mass density ρ is bent into a circular loop with centre at O as shown. The moment of inertia of the loop about the axis XX′ is

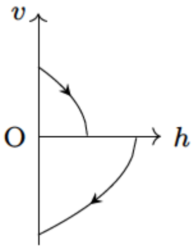


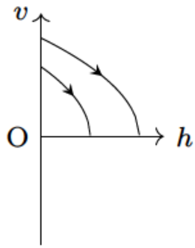
(A) $\frac{\rho L^3}{8\pi^2}$ (B) $\frac{\rho L^3}{16\pi^2}$ (C) $\frac{5\rho L^3}{16\pi^2}$ (D) $\frac{3\rho L^3}{8\pi^2}$

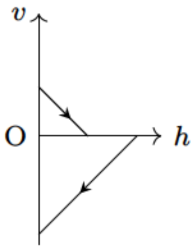
Q 15. A wind-powered generator converts wind energy into electric energy. Assume that the generator converts a fixed fraction of the wind energy intercepted by its blades into electric energy. For wind speed v, the electric power output will be proportional to
(A) v (B) v^2 (C) v^3 (D) v^4

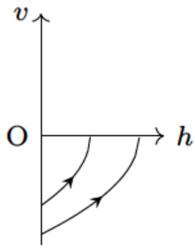
Q 16. A long horizontal rod has a bead which can slide along its length and is initially placed at a distance L from one end A of the rod. The rod is set in angular motion about A with a constant angular acceleration α. If the coefficient of friction between the rod and bead is μ, and gravity is neglected, then the time after which the bead starts slipping is
(A) $\sqrt{\frac{\mu}{\alpha}}$ (B) $\frac{\mu}{\sqrt{\alpha}}$ (C) $\frac{1}{\sqrt{\mu\alpha}}$ (D) infinitesimal

Q 17. A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height $d/2$. Neglecting subsequent motion and air resistance, its velocity v varies with height h above the ground as

(A)


(B)


(C)


(D)


Q 18. The dimensions of $\frac{1}{2}\epsilon_0 E^2$ (where ϵ_0 is permittivity of free space and E is electric field) is

(A) $[\mathrm{MLT^{-1}}]$ (B) $[\mathrm{ML^2T^{-2}}]$

(C) $[\mathrm{ML^{-1}T^{-2}}]$ (D) $[\mathrm{ML^2T^{-1}}]$

Q 19. Two monatomic ideal gases 1 and 2 of molecular masses m_1 and m_2 respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas 1 to that in the gas 2 is given by

(A) $\sqrt{\frac{m_1}{m_2}}$ (B) $\sqrt{\frac{m_2}{m_1}}$ (C) $\frac{m_1}{m_2}$ (D) $\frac{m_2}{m_1}$

Q 20. Imagine an atom made up of proton and a hypothetical particle of double the mass of the electron but having the same charge as the electron. Apply the Bohr atom model and consider all possible transitions of this hypothetical particle to the first excited level. The longest wavelength photon that will be emitted has wavelength λ (given in terms of the Rydberg constant R for the hydrogen atom) equal to
(A) $9/(5R)$ (B) $36/(5R)$ (C) $18/(5R)$ (D) $4/R$

Q 21. Two radioactive materials X_1 and X_2 have decay constants 10λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2 will be $1/e$ after a time
(A) $1/(10\lambda)$ (B) $1/(11\lambda)$ (C) $11/(10\lambda)$ (D) $1/(9\lambda)$

Q 22. The electron in a hydrogen atom makes a transition from an excited state to the ground state. Which of the following statement is true?

(A) Its kinetic energy increases and its potential and total energies decrease.

(B) Its kinetic energy decreases, potential energy increases and its total energy remains the same.

(C) Its kinetic and total energy decrease and its potential energy increases.

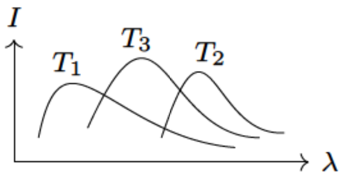
(D) Its kinetic, potential and total energies decrease.

Q 23. A monatomic ideal gas, initially at temperature T_1, is enclosed in a cylinder fitted with a frictionless piston. The gas is allowed to expand adiabatically to a temperature T_2 by releasing the piston suddenly. If L_1 and L_2 are the lengths of the gas column before and after expansion respectively, then T_1/T_2 is given by

(A) $(L_1/L_2)^{2/3}$ (B) L_1/L_2

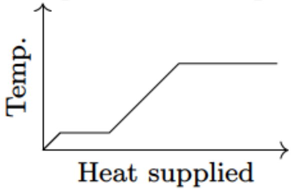
(C) L_2/L_1 (D) $(L_2/L_1)^{2/3}$

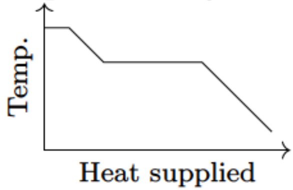
Q 24. The plots of intensity *versus* wavelength for three black bodies at temperatures T_1, T_2 and T_3, respectively are as shown in the figure. Their temperatures are such that

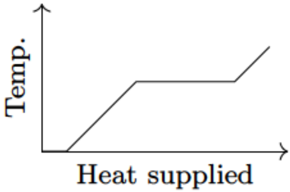


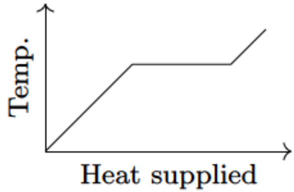
(A) $T_1 > T_2 > T_3$ (B) $T_1 > T_3 > T_2$
(C) $T_2 > T_3 > T_1$ (D) $T_3 > T_2 > T_1$

Q 25. A block of ice at $-10\,^\circ\mathrm{C}$ is slowly heated and converted to steam at $100\,^\circ\mathrm{C}$. Which of the following curves represents the phenomenon qualitatively?

(A)


(B)


(C)


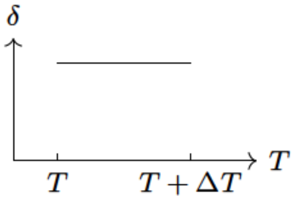
(D)


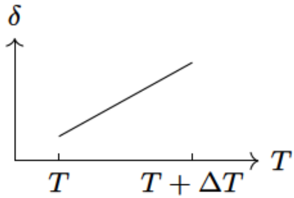
Q 26. Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways. The work done by the gas is W_1 if the process is purely isothermal, W_2 if purely isobaric and W_3 if purely adiabatic, then,

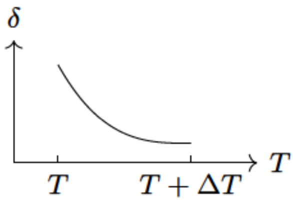
(A) $W_2 > W_1 > W_3$ (B) $W_2 > W_3 > W_1$

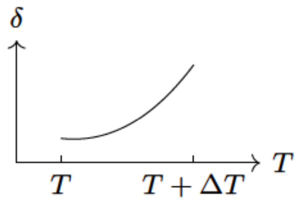
(C) $W_1 > W_2 > W_3$ (D) $W_1 > W_3 > W_2$

Q 27. An ideal gas is initially at temperature T and volume V. Its volume is increased by ΔV due to an increase in temperature ΔT, pressure remaining constant. The quantity $\delta = \frac{1}{V}\frac{\Delta V}{\Delta T}$ varies with temperature as

(A) 

(B) 

(C) 

(D) 

Q 28. Electrons with energy 80 keV are incident on the tungsten target of an X-ray tube. K-shell electrons of tungsten have 72.5 keV energy. X-rays emitted by the tube contains only,

(A) a continuous X-ray spectrum (Bremsstrahlung) with a minimum wavelength of ≈ 0.155 Å.

(B) a continuous X-ray spectrum with all wavelengths.

(C) the characteristic X-ray spectrum of tungsten.

(D) a continuous X-ray spectrum with a minimum wavelength of ≈ 0.155 Å and the characteristic X-ray spectrum of tungsten.

Q 29. In a compound microscope, the intermediate image is

(A) virtual, erect and magnified

(B) real, erect and magnified

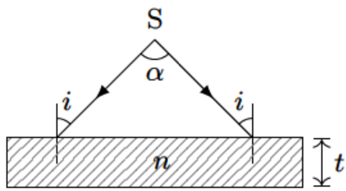
(C) real, inverted and magnified

(D) virtual, erect and reduced

Q 30. A hollow double concave lens is made of very thin transparent material. It can be filled with air or either of two liquids L_1 or L_2 having refractive indices n_1 and n_2, respectively ($n_2 > n_1 > 1$). The lens will diverge parallel beam of light if it is filled with

(A) air and placed in air.
(B) air and immersed in L_1.
(C) L_1 and immersed in L_2.
(D) L_2 and immersed in L_1.

Q 31. A diverging beam of light from a source S having divergence angle α falls symmetrically on a glass slab as shown. The angles of incidence of the two extreme rays are equal. If the thickness of the glass slab is t and its refractive index is n, then the divergence angle of the emergent beam is



(A) zero (B) α (C) $\sin^{-1}(1/n)$ (D) $2\sin^{-1}(1/n)$

Q 32. In a double slit experiment instead of taking slits of equal widths, one slit is made twice as wide as the other, then in the interference pattern,

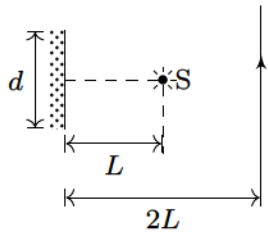
(A) the intensities of both maxima and the minima increase.

(B) the intensity of the maxima increases and the minima has zero intensity.

(C) the intensity of maxima decreases and that of minima increases.

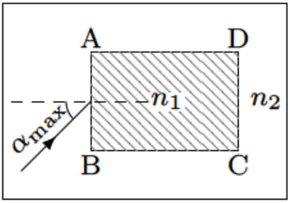
(D) the intensity of maxima decreases and the minima has zero intensity.

Q 33. A point source of light S, placed at a distance L in front of the centre of a plane mirror of width d, hangs vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror at a distance $2L$ from it as shown. The greatest distance over which he can see image of the light source in the mirror is



(A) $d/2$ (B) d (C) $2d$ (D) $3d$

Q 34. A rectangular glass slab ABCD of refractive index n_1 is immersed in water of refractive index n_2 ($n_1 > n_2$). A ray of light is incident at the surface AB of the slab as shown. The maximum value of the angle of incidence α_{max}, such that the ray comes out only from the other surface CD, is given by



(A) $\sin^{-1}\left[\frac{n_1}{n_2}\cos\left(\sin^{-1}\frac{n_2}{n_1}\right)\right]$

(B) $\sin^{-1}\left[n_1\cos\left(\sin^{-1}\frac{1}{n_2}\right)\right]$

(C) $\sin^{-1}\left(\frac{n_1}{n_2}\right)$

(D) $\sin^{-1}\left(\frac{n_2}{n_1}\right)$

Q 35. A train moves towards a stationary observer with speed 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1. If the train's speed is reduced to 17 m/s, the frequency registered is f_2. If the speed of sound is 340 m/s then the ratio f_1/f_2 is

(A) 18/19 (B) 1/2 (C) 2 (D) 19/18

Answers

1. A
2. B
3. B
4. C
5. C
6. C
7. B
8. B
9. D
10. D
11. A
12. B
13. C
14. D
15. C
16. A
17. A
18. C
19. B
20. C
21. D
22. A
23. D
24. B
25. A
26. A
27. C
28. D
29. C
30. D
31. B
32. A
33. D
34. A
35. D

Main Paper

The main paper in physics is of 2 hour duration. It has 10 questions of total marks 100.

Descriptive

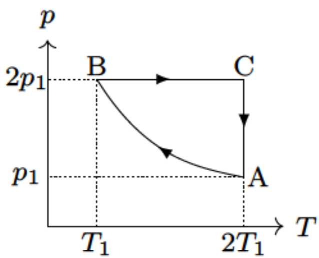
The paper has 10 descriptive questions of 10 marks each.

One of these questions has two parts (a) "A hydrogen like atom of. . . " and (b) "When a beam of. . . ". These parts are placed as two different questions. Similarly, one more question has two parts (a) "A convex lens of focal length. . . " and (b) "A glass plate of refractive index. . . ". These parts are also placed as two different questions. Thus, total number of questions given here are 12. Solve all of them.

Q 1. A hydrogen like atom of atomic number Z is in an excited state of quantum number $2n$. It can emit a maximum energy photon of 204 eV. If it makes a transition to quantum state n, a photon of energy 40.8 eV is emitted. Find n, Z and the ground state energy (in eV) of this atom. Also calculate the minimum energy (in eV) that can be emitted by this atom during de-excitation. Ground state energy of hydrogen atom is -13.6 eV.

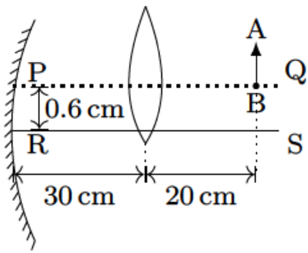
Q 2. When a beam of 10.6 eV photons of intensity $2.0\ \mathrm{W/m^2}$ falls on a platinum surface of area $1.0 \times 10^{-4}\ \mathrm{m^2}$ and work function 5.6 eV, 0.53% of the incident photons eject photoelectrons. Find the number of photoelectrons emitted per second and their minimum and maximum energies (in eV). [Take $1\ \mathrm{eV} = 1.6 \times 10^{-19}\ \mathrm{J}$.]

Q 3. Two moles of an ideal monatomic gas is taken through a cycle ABCA as shown in the p-T diagram. During the process AB, pressure and temperature of the gas vary such that pT = constant. If $T_1 = 300$ K, calculate, [Give answers in terms of the gas constant R.]



(a) the work done on the gas in the process AB.
(b) the heat absorbed or released by the gas in each of the processes.

Q 4. A convex lens of focal length 15 cm and a concave mirror of focal length 30 cm are kept with their optic axis PQ and RS parallel but separated in vertical direction by 0.6 cm as shown. The distance between the lens and mirror is 30 cm. An upright object AB of height 1.2 cm is placed on the optic axis PQ of the lens at a distance of 20 cm from the lens. If A′B′ is the image after refraction from the lens and the reflection from the mirror, find the distance A′B′ from the pole of the mirror and obtain its magnification. Also locate positions of A' and B' with respect to the optic axis RS.

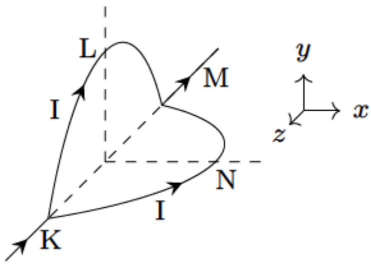


Q 5. A glass plate of refractive index 1.5 is coated with a thin layer of thickness t and refractive index 1.8. Light of wavelength λ travelling in air is incident normally on the layer. It is partly reflected at the upper and the lower surfaces of the layer and the two reflected rays interfere. Write the condition for their constructive interference. If $\lambda = 648$ nm, obtain the least value of t for which the rays interfere constructively.

Q 6. A 3.6 m long pipe resonates with a source of frequency 212.5 Hz when water level is at certain height in the pipe. Find the heights of water level (from the bottom of the pipe) at which resonances occur. Neglect end correction. Now the pipe is filled to height $H (\approx 3.6\ \text{m})$. A small hole is drilled very close to its bottom and water is allowed to leak. Obtain an expression for the rate of fall of water level in the pipe as a function of H. If the radii of the pipe and the hole are 2×10^{-2} m and 1×10^{-3} m respectively, calculate the time interval between the occurrence of first two resonances. [Speed of sound in air is 340 m/s and $g = 10\ \text{m/s}^2$.]

Q 7. Four point charges $+8\ \mu\mathrm{C}$, $-1\ \mu\mathrm{C}$, $-1\ \mu\mathrm{C}$, and $+8\ \mu\mathrm{C}$ are fixed at the points $-\sqrt{27/2}$ m, $-\sqrt{3/2}$ m, $+\sqrt{3/2}$ m and $+\sqrt{27/2}$ m respectively on the y-axis. A particle of mass 6×10^{-4} kg and charge $+0.1\ \mu\mathrm{C}$ moves along the x direction. Its speed at $x = +\infty$ is v_0. Find the least value of v_0 for which the particle will cross the origin. Also find the kinetic energy of the particle at the origin. Assume that space is gravity free. $\left[\frac{1}{4\pi\epsilon_0} = 9 \times 10^9\ \mathrm{Nm}^2/\mathrm{C}^2.\right]$

Q 8. A circular loop of radius R is bent along a diameter and given a shape as shown in the figure. One of the semicircles (KNM) lies in the x-z plane and the other one (KLM) in the y-z plane with their centres at origin. Current I is flowing through each of the semicircles as shown in the figure.



(a) A particle of charge q is released at the origin with a velocity $\vec{v} = -v_0\hat{\imath}$. Find the instantaneous force $\vec{F}$ on the particle. Assume that space is gravity free.

(b) If an external uniform magnetic field $B_0\hat{\jmath}$ is applied determine the force $\vec{F_1}$ and $\vec{F_2}$ on the semicircles KLM and KNM due to the field and the net force $\vec{F}$ on the loop.

Q 9. A thermocol vessel contains 0.5 kg of distilled water at 30 °C. A metal coil of area 5×10^{-3} m^2, number of turns 100, mass 0.06 kg and resistance 1.6 Ω is lying horizontally at the bottom of the vessel. A uniform time varying magnetic field is set-up to pass vertically through the coil at time $t = 0$. The field is first increased from 0 to 0.8 T at a constant rate between 0 s and 0.2 s and then decreased to zero at the same rate between 0.2 s and 0.4 s. The cycle is repeated 12000 times. Make sketches of the current through the coil and the power dissipated in the coil as a function of time for the first two cycles. Clearly indicate the magnitudes of the quantities on the axes. Assume that no heat is lost to the vessel or the surrounding. Determine the final temperature of the water under thermal equilibrium. Specific heat of metal = 500 J/kg K and the specific heat of water = 4200 J/kg K. Neglect the inductance of coil.

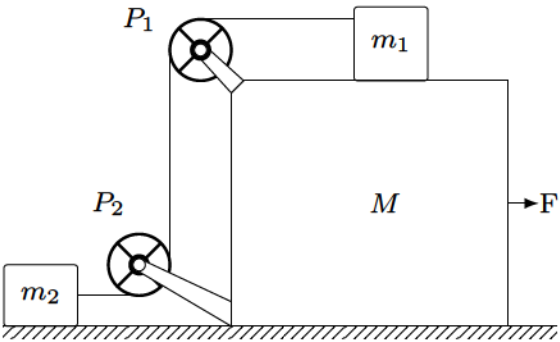
Q 10. A rod AB of mass M and length L is lying on a horizontal frictionless surface. A particle of mass m travelling along the surface hits the end A of the rod with velocity v_0 in the direction perpendicular to AB. The collision is elastic. After the collision the particle comes to rest.

(a) Find the ratio m/M.

(b) A point P on the rod is at rest immediately after collision. Find the distance AP.

(c) Find the linear speed of the point P a time $\frac{\pi L}{3v_0}$ after the collision.

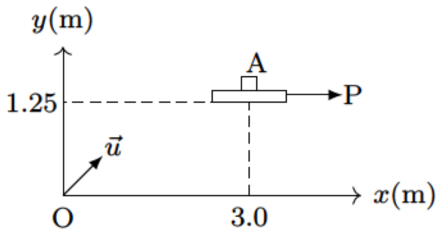
Q 11. In the figure masses m_1, m_2 and M are 20 kg, 5 kg and 50 kg respectively. The coefficient of friction between M and ground is zero. The coefficient of friction between m_1 and M and between m_2 and ground is 0.3. The pulleys and the strings are massless. The string is perfectly horizontal between P_1 and m_1 and also between P_2 and m_2. The string is perfectly vertical between P_1 and P_2. An external horizontal force F is applied to the mass M. [Take $g = 10\ \mathrm{m/s^2}$.]



(a) Draw a free body diagram of mass M, clearly showing all the forces.

(b) Let the magnitude of the force of friction between m_1 and M be f_1 and that between m_2 and ground be f_2. For a particular force F it is found that $f_1 = 2f_2$. Find f_1 and f_2. Write equations of motion of all the masses. Find F, tension in the string and acceleration of the masses.

Q 12. An object A is kept fixed at the point $x = 3$ m and $y = 1.25$ m on a plank P raised above the ground. At time $t = 0$ the plank starts moving along the $+x$ direction with an acceleration $1.5\ \text{m/s}^2$. At the same instant a stone is projected from the origin with a velocity $\vec{u}$ as shown. A stationary person on the ground observes the stone hitting the object during its downward motion at an angle of $45°$ to the horizontal. All the motions are in x-y plane. Find $\vec{u}$ and the time after which the stone hits the object. [Take $g = 10\ \text{m/s}^2$.]



Answers

1. $n = 2$, $Z = 4$, -217.6 eV, 10.58 eV
2. 6.25×10^{11}, zero, 5.0 eV
3. (a) $1200R$ (b) $Q_{AB} = -2100R$, $Q_{BC} = 1500R$, $Q_{CA} = 831.6R$
4. 15 cm, $-3/2$
5. $3.6t = \left(n + \frac{1}{2}\right)\lambda$ with $n = 0, 1, 2, \ldots$, $t_{\min} = 90$ nm
6. 3.2 m, 2.4 m, 1.6 m, 0.8 m, $-\frac{\mathrm{d}H}{\mathrm{d}t} = 1.11 \times 10^{-2}\sqrt{H}$, 43.5 s
7. 3 m/s, 3×10^{-4} J
8. (a) $-\frac{\mu_0 q v_0 I}{4R}\hat{k}$ (b) $\vec{F}_1 = \vec{F}_2 = \vec{F}/2 = 2B_0 I R\,\hat{\imath}$
9. 35.6 °C
10. (a) $\frac{1}{4}$ (b) $\frac{2}{3}L$ (c) $\frac{v_0}{2\sqrt{2}}$
11. (b) $f_1 = 30$ N, $f_2 = 15$ N, $F = 60$ N, $T = 18$ N, $a = \frac{3}{5}$ m/s^2
12. $(3.75\,\hat{\imath} + 6.25\,\hat{\jmath})$ m/s, 1 s

IIT JEE 1999

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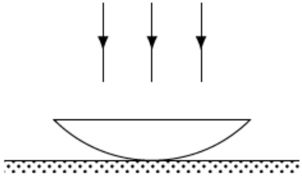
Paper

The paper is divided into two parts, (A) and (B). The questions in part (A) has (i) objective questions with single option correct and (ii) objective questions with one or more option(s) correct. The questions in part (B) has descriptive questions. Total marks of the paper is 200 and there is no negative marking.

One Option Correct

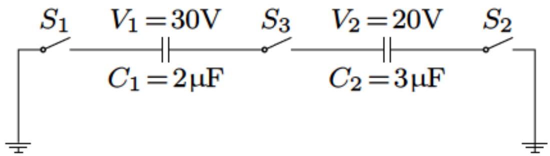
This section is part (A) of the paper. The section has 25 questions. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Each question is of two mark.

Q 1. A thin slice is cut out of a glass cylinder along a plane parallel to its axis. The slice is placed on a flat plate as shown. The observed interference fringes from this combination shall be



(A) straight.
(B) circular.
(C) equally spaced.
(D) having fringe spacing which increases as we go outwards.

Q 2. For the circuit shown, which of the following statements is true?



(A) with S_1 closed, $V_1 = 15$ V, $V_2 = 20$ V.
(B) with S_3 closed, $V_1 = V_2 = 25$ V.
(C) with S_1 and S_2 closed, $V_1 = V_2 = 0$.
(D) with S_1 and S_3 closed, $V_1 = 30$ V, $V_2 = 20$ V.

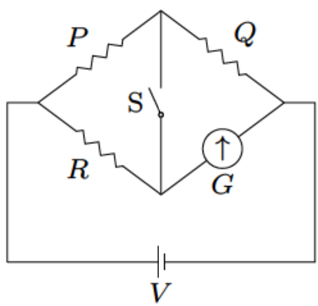
Q 3. Two identical metal plates are given positive charges q_1 and q_2 ($< q_1$) respectively. If they are now brought close together to form a parallel plate capacitor with capacitance C, the potential difference between them is

(A) $\frac{q_1+q_2}{2C}$ (B) $\frac{q_1+q_2}{C}$ (C) $\frac{q_1-q_2}{C}$ (D) $\frac{q_1-q_2}{2C}$

Q 4. A charged particle is released from rest in a region of steady and uniform electric and magnetic fields which are parallel to each other. The particle will move in a

(A) straight line (B) circle (C) helix (D) cycloid

Q 5. In the circuit shown $P \neq R$, the reading of galvanometer is same with switch S open or closed. Then,



(A) $I_R = I_G$ (B) $I_P = I_G$ (C) $I_Q = I_G$ (D) $I_Q = I_R$

Q 6. A circular loop of radius R, carrying current I, lies in x-y plane with its centre at origin. The total magnetic flux through x-y plane is

(A) directly proportional to I.

(B) directly proportional to R.

(C) inversely proportional to R.

(D) zero.

Q 7. Two identical circular loops of metal wire are lying on a table without touching each other. Loop A carries a current which increases with time. In response, the loop B

(A) remains stationary.
(B) is attracted by the loop A.
(C) is repelled by the loop A.
(D) rotates about its CM, with CM fixed.

Q 8. A coil of inductance 8.4 mH and resistance 6 Ω is connected to a 12 V battery. The current in the coil is 1 A at approximately the time

(A) 500 s (B) 20 s (C) 35 ms (D) 1 ms

Q 9. A closed compartment containing gas is moving with some acceleration in horizontal direction. Neglect effect of gravity. Then, the pressure in the compartment is

(A) same everywhere (B) lower in front side

(C) lower in rear side (D) lower in upper side

Q 10. A particle free to move along the x-axis has potential energy given by $U(x) = k\left[1 - e^{-x^2}\right]$ for $-\infty \leq x \leq +\infty$, where k is a positive constant of appropriate dimensions. Then,

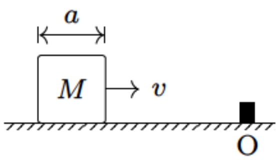
(A) at points away from the origin, the particle is in unstable equilibrium.

(B) for any finite non-zero value of x, there is a force directed away from the origin.

(C) if its total mechanical energy is $k/2$, it has its minimum kinetic energy at origin.

(D) for small displacement from $x = 0$, the motion is simple harmonic.

Q 11. A cubical block of side a is moving with velocity v on a horizontal smooth plane (see figure). It hits a ridge at point O. The angular speed of the block after it hits O is



(A) $\frac{3v}{4a}$ (B) $\frac{3v}{2a}$ (C) $\frac{\sqrt{3}}{\sqrt{2}a}$ (D) zero

Q 12. A smooth sphere A is moving on a frictionless horizontal plane with angular velocity ω and centre of mass velocity v. It collides elastically and head on with an identical sphere B at rest. Neglect friction everywhere. After the collision their angular speeds are ω_A and ω_B respectively. Then,

(A) $\omega_A < \omega_B$ (B) $\omega_A = \omega_B$ (C) $\omega_A = \omega$ (D) $\omega_B = \omega$

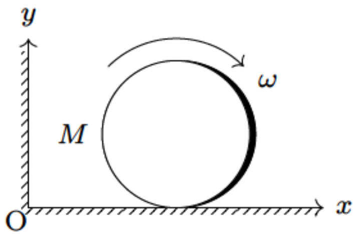
Q 13. A concave lens of glass, refractive index 1.5, has both surfaces of the same radius of curvature R. On immersion in a medium of refractive index 1.75, it will behave as a

(A) convergent lens of focal length $3.5R$
(B) convergent lens of focal length $3.0R$
(C) divergent lens of focal length $3.5R$
(D) divergent lens of focal length $3.0R$

Q 14. Yellow light is used in a single slit diffraction experiment with slit width of 0.6 mm. If yellow light is replaced by X-rays, then the observed pattern will reveal

(A) that the central maximum is narrower.
(B) more number of fringes.
(C) less number of fringes.
(D) no diffraction pattern.

Q 15. A disc of mass M and radius R is rolling with angular speed ω on a horizontal plane (see figure). The magnitude of angular momentum of the disc about the origin O is



(A) $\frac{1}{2}MR^2\omega$ (B) $MR^2\omega$ (C) $\frac{3}{2}MR^2\omega$ (D) $2MR^2\omega$

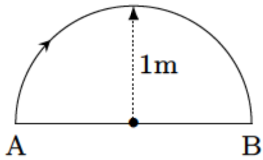
Q 16. A spring of force constant k is cut into two pieces such that one piece is double the length of the other. Then the long piece will have a force constant of
(A) $\frac{2}{3}k$ (B) $\frac{3}{2}k$ (C) $3k$ (D) $6k$

Q 17. A gas mixture consists of 2 mol of oxygen and 4 mol of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is

(A) $4RT$ (B) $15RT$ (C) $9RT$ (D) $11RT$

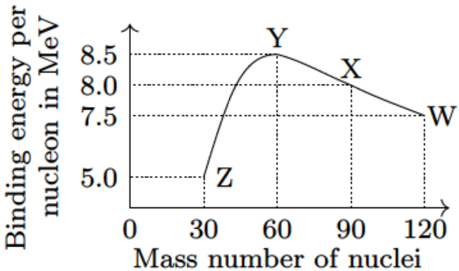
Q 18. The ratio of the speed of sound in nitrogen gas to that in helium gas, at 300 K is
(A) $\sqrt{2/7}$ (B) $\sqrt{1/7}$ (C) $\sqrt{3}/5$ (D) $\sqrt{6}/5$

Q 19. In 1.0 s, a particle goes from point A to point B, moving in a semicircle of radius 1.0 m (see figure). The magnitude of the average velocity is



(A) 3.14 m/s (B) 2.0 m/s (C) 1.0 m/s (D) zero

Q 20. Binding energy per nucleon *versus* mass number curve for nuclei is shown in the figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is



(A) $Y \rightarrow 2Z$ (B) $W \rightarrow X + Z$
(C) $W \rightarrow 2Y$ (D) $X \rightarrow Y + Z$

Q 21. Which of the following is a correct statement?

(A) Beta rays are same as cathode rays.

(B) Gamma rays are high energy neutrons.

(C) Alpha particles are singly ionized helium atoms.

(D) Protons and neutrons have exactly the same mass.

Q 22. A particle of mass M at rest decays into two particles of masses m_1 and m_2 having non-zero velocities. The ratio of the de-Broglie wavelengths of the particles, λ_1/λ_2 is

(A) m_1/m_2 (B) m_2/m_1 (C) 1 (D) $\sqrt{m_2}/\sqrt{m_1}$

Q 23. In hydrogen spectrum the wavelength of H_α line is 656 nm; whereas in the spectrum of a distant galaxy H_α line wavelength is 706 nm. Estimated speed of galaxy with respect to earth is

(A) 2×10^8 m/s (B) 2×10^7 m/s

(C) 2×10^6 m/s (D) 2×10^5 m/s

Q 24. ^{22}Ne nucleus, after absorbing energy, decays into two α-particles and an unknown nucleus. The unknown nucleus is
(A) nitrogen (B) carbon (C) boron (D) oxygen

Q 25. Order of magnitude of density of uranium nucleus is [Given $R_0 \approx 1.1 \times 10^{-15}$ m and $m_p = 1.67 \times 10^{-27}$ kg.]

(A) 10^{20} kg/m^3 (B) 10^{17} kg/m^3
(C) 10^{14} kg/m^3 (D) 10^{11} kg/m^3

One or More Option(s) Correct

This section is also part (A) of the paper. The section has 10 questions. Each question has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of three marks.

Q 26. The coordinates of a particle moving in a plane are given by $x = a\cos pt$ and $y = b\sin pt$ where a, $b\,(< a)$ and p are positive constants of appropriate dimensions. Then,

(A) the path of the particle is an ellipse.

(B) the velocity and acceleration of the particle are normal to each other at $t = \frac{\pi}{2p}$.

(C) the acceleration of the particle is always directed towards a focus.

(D) the distance travelled by the particle in time interval $t = 0$ to $t = \frac{\pi}{2p}$ is a.

Q 27. Three simple harmonic motions in the same direction having the same amplitude and same period are superimposed. If each differ in phase from the next by $45°$, then,

(A) the resultant amplitude is $\left(1+\sqrt{2}\right)a$.

(B) the phase of the resultant motion relative to the first is $90°$.

(C) the energy associated with the resulting motion is $\left(3+2\sqrt{2}\right)$ times the energy associated with any single motion.

(D) the resulting motion is not simple harmonic.

Q 28. As a wave propagates,

(A) the wave intensity remains constant for a plane wave.

(B) the wave intensity decreases as the inverse of the distance from the source for a spherical wave.

(C) the wave intensity decreases as the inverse square of the distance from the source for a spherical wave.

(D) total intensity of the spherical wave over spherical surface centred at the source remains constant at all times.

Q 29. The half-life period of a radioactive element x is same as the mean life time of another radioactive element y. Initially both of them have the same number of atoms. Then,

(A) x and y have the same decay rate initially.
(B) x and y decay at the same rate always.
(C) y will decay at a faster rate than x.
(D) x will decay at a faster rate than y.

Q 30. A bimetallic strip is formed out of two identical strips - one of copper and the other of brass. The coefficients of linear expansion of the two metals are α_C and α_B. On heating, the temperature of the strip goes up by ΔT and the strip bends to form an arc of radius of curvature R. Then, R is

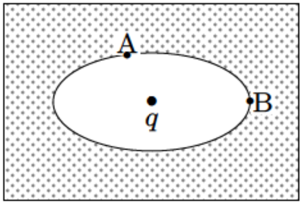
(A) proportional to ΔT.

(B) inversely proportional to ΔT.

(C) proportional to $|\alpha_B - \alpha_C|$.

(D) inversely proportional to $|\alpha_B - \alpha_C|$.

Q 31. An elliptical cavity is carved within a perfect conductor. A positive charge q is placed at the centre of the cavity. The points A and B are on the cavity surface as shown in the figure. Then,



(A) electric field near A in the cavity = electric field near B in the cavity.
(B) charge density at A = charge density at B.
(C) potential at A = potential at B.
(D) total electric field flux through the surface of the cavity is q/ϵ_0.

Q 32. $y(x,t) = \frac{0.8}{(4x+5t)^2+5}$ represents a moving pulse where x and y are in metre and t is in second. Then,

(A) pulse is moving in positive x direction.

(B) in 2 s it will travel a distance of 2.5 m.

(C) its maximum displacement is 0.16 m.

(D) it is a symmetric pulse.

Q 33. In a wave motion $y = a\sin(kx - \omega t)$, y can represent

(A) electric field (B) magnetic field

(C) displacement (D) pressure

Q 34. Standing waves can be produced

(A) on a string clamped at both ends.

(B) on a string clamped at one end and free at the other.

(C) when incident wave gets reflected from a wall.

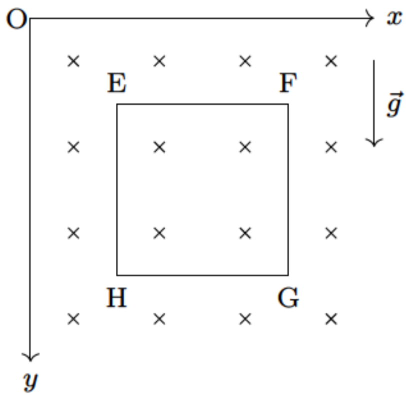
(D) when two identical waves with a phase difference of π are moving in the same direction.

Q 35. When a potential difference is applied across, the current passing through
(A) an insulator at 0 K is zero.
(B) a semiconductor at 0 K is zero.
(C) a metal at 0 K is finite.
(D) a p-n diode at 300 K is finite, if it is reverse biased.

Descriptive

This section is part (B) of the paper. There are 12 descriptive questions in this section. Each question is of 10 marks. Note: In original paper, one of the question is divided into two parts (a) "A quarter cylinder…" and (b) "Photoelectrons are emitted…".

Q 36. A magnetic field $B = (B_0 y/a)\,\hat{k}$ is acting into the paper in the $+z$ direction. B_0 and a are positive constants. A square loop $EFGH$ of side a, mass m and resistance R in x-y plane starts falling under the influence of gravity. Note the directions of x and y in the figure. Find,



(a) the induced current in the loop and indicate its direction.

(b) the total Lorentz force acting on the loop and indicate its direction.

(c) an expression for the speed of the loop $v(t)$ and its terminal velocity.

Q 37. The region between $x = 0$ and $x = L$ is filled with uniform magnetic field $-B_0\hat{k}$. A particle of mass m, positive charge q and velocity $v_0\hat{\imath}$ travels along x-axis and enters the region of the magnetic field. Neglect the gravity throughout the question.

(a) Find the value of L if the particle emerges from the region of magnetic field with its final velocity at an angle $30°$ to its initial velocity.

(b) Find the final velocity of the particle and the time spent by it in the magnetic field, if the magnetic field now expands to $2.1L$.

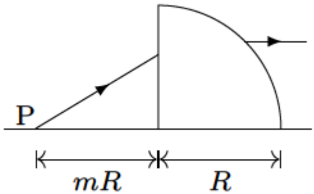
Q 38. A wooden stick of length L, radius R and density ρ has a small metal piece of mass m (of negligible volume) attached to its one end. Find the minimum value for the mass m (in terms of given parameters) that would make the stick float vertically in equilibrium in a liquid of density σ $(> \rho)$.

Q 39. A long wire PQR is made by joining two wires PQ and QR of equal radii. PQ has length 4.8 m and mass 0.06 kg. QR has length 2.56 m and mass 0.2 kg. The wire PQR is under a tension of 80 N. A sinusoidal wave pulse of amplitude 3.5 cm is sent along the wire PQ from the end P. No power is dissipated during the propagation of the wave pulse. Calculate,

(a) the time taken by the wave pulse to reach the other end R.

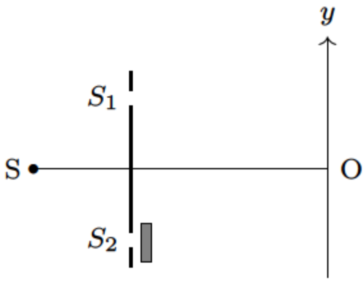
(b) the amplitude of the reflected and transmitted wave pulse after the incident wave pulse crosses the joint Q.

Q 40. A quarter cylinder of radius R and refractive index 1.5 is placed on a table. A point object P is kept at a distance mR from it. Find the value of m for which a ray from P will emerge parallel to the table as shown in the figure.



Q 41. The x-y plane is the boundary between two transparent media. Medium 1 with $z \geq 0$ has a refractive index $\sqrt{2}$ and medium 2 with $z < 0$ has refractive index $\sqrt{3}$. A ray of light in medium 1, given by vector $\vec{A} = 6\sqrt{3}\,\hat{\imath} + 8\sqrt{3}\,\hat{\jmath} - 10\,\hat{k}$, is incident on the plane of separation. Find the unit vector in the direction of the refracted ray in medium 2.

Q 42. Young's double slit experiment is done in a medium of refractive index 4/3. A light of 600 nm wavelength is falling on the slits having 0.45 mm separation. The lower slit S_2 is covered by thin glass sheet of thickness 10.4 µm and refractive index 1.5. The interference pattern is observed on a screen placed 1.5 m from the slits as shown in the figure.



(a) Find the location of central maximum (bright fringe with zero path difference) on the y-axis.

(b) Find the light intensity at point O relative to the maximum fringe intensity.

(c) Now, if 600 nm light is replaced by white light of range 400 nm to 700 nm, find the wavelengths of the light that form maxima exactly at point O.

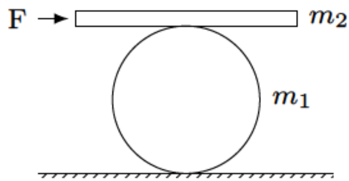
[All wavelengths in the problem are for the given medium of refractive index 4/3. Ignore dispersion.]

Q 43. Two moles of an ideal monatomic gas initially at pressure p_1 and volume V_1 undergo an adiabatic compression until its volume is V_2. Then the gas is given heat Q at constant volume V_2. [Give answer in terms of p_1, V_1, V_2, Q and R.]

(a) Sketch the complete process on a p-V diagram.

(b) Find the total work done by the gas, the total change in its internal energy and the final temperature of the gas.

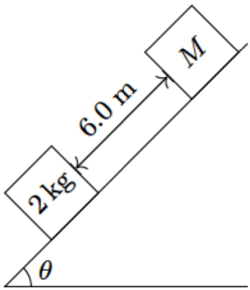
Q 44. A man pushes a cylinder of mass m_1 with the help of a plank of mass m_2 as shown in the figure. There is no slipping at any contact. The horizontal component of the force applied by the man is F. Find,



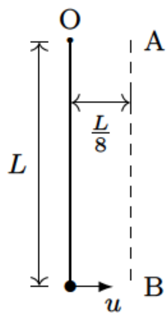
(a) the accelerations of the plank and the centre of mass of the cylinder.

(b) the magnitudes and directions of frictional forces at contact point.

Q 45. Two blocks of mass 2 kg and M are at rest on an inclined plane and are separated by a distance of 6.0 m as shown. The coefficient of friction between each block and the inclined plane is 0.25. The 2 kg block is given a velocity of 10.0 m/s up the inclined plane. It collides with M, comes back and has a velocity of 1.0 m/s when it reaches its initial position. The other block M after the collision moves 0.5 m up and comes to rest. Calculate the coefficient of restitution between the blocks and the mass of the block M. [Take $\sin\theta \approx \tan\theta = 0.05$ and $g = 10\ \mathrm{m/s^2}$.]



Q 46. A particle is suspended vertically from a point O by an inextensible massless string of length L. A vertical line AB is at a distance $L/8$ from O as shown in the figure. The object is given a horizontal velocity u. At some point, its motion ceases to be circular and eventually the object passes through the line AB. At the instant of crossing AB, its velocity is horizontal. Find u.



Q 47. Photelectrons are emitted when 400 nm radiation is incident on a surface of work function 1.9 eV. These photoelectrons pass through a region containing α-particles. A maximum energy electron combines with an α-particle to form a He^+ ion, emitting a single photon in this process. He^+ ions thus formed are in their fourth excited state. Find the energies (in eV) of the photons lying in the 2 eV to 4 eV range, that are likely to be emitted during and after the combination. [Take $h = 4.14 \times 10^{-15}$ eV s.]

Q 48. A non-conducting disc of radius a and uniform positive surface charge density σ is placed on the ground with its axis vertical. A particle of mass m and positive charge q is dropped, along the axis of the disc from a height H with zero initial velocity. The particle has $q/m = 4\epsilon_0 g/\sigma$.

(a) Find the value of H if the particle just reaches the disc.

(b) Sketch the potential energy of the particle as a function of its height and find its equilibrium position.

Answers

1. A
2. D
3. D
4. A
5. A
6. D
7. C
8. D
9. B
10. D
11. A
12. C
13. A
14. A
15. C
16. B
17. D
18. C
19. B
20. C
21. A
22. C
23. B
24. B
25. B
26. A, B, C
27. A, C
28. A, C, D
29. C
30. B, D
31. C, D
32. B, C, D
33. A, B, C, D
34. A, B, C
35. A, B, D
36. (a) $\frac{B_0 a v}{R}$, anticlockwise (b) $-\frac{B_0^2 a^2 v}{R}\hat{\jmath}$ (c) $v = \frac{mgR}{B_0^2 a^2}\left[1 - e^{-\frac{B_0^2 a}{mR}}\right.$
$v_t = \frac{gmR}{B_0^2 a^2}$
37. (a) $\frac{mv_0}{2B_0 q}$ (b) $-v_0\hat{\imath}$, $\frac{\pi m}{B_0 q}$
38. $\pi R^2 L\sqrt{\rho}\left(\sqrt{\sigma} - \sqrt{\rho}\right)$
39. (a) 0.14 s (b) $A_r = 1.5$ cm, $A_t = 2.0$ cm
40. $4/3$
41. $\frac{1}{5\sqrt{2}}\left(3\hat{\imath} + 4\hat{\jmath} - 5\hat{k}\right)$

42. (a) -4.33 mm (b) $I = \frac{3}{4}I_{\text{max}}$ (c) 650 nm, 433.33 nm

43. (a) See solution
(b) $-\frac{3}{2}p_1V_1\left[(V_1/V_2)^{\frac{2}{3}}-1\right]$, $\frac{3}{2}p_1V_1\left[(V_1/V_2)^{\frac{2}{3}}-1\right]+Q$, $\frac{Q}{3R}+\frac{p_1V_1}{2R}(V_1/V_2)^{\frac{2}{3}}$

44. (a) $a_{\text{CM}} = \frac{4F}{3m_1+8m_2}$, $a_{\text{plank}} = 2a_{\text{CM}}$ (b) $\frac{3Fm_1}{3m_1+8m_2}$, $\frac{Fm_1}{3m_1+8m_2}$

45. $e = 0.84$, $M = 15.12$ kg

46. $u = \sqrt{gL\left(2+\frac{3\sqrt{3}}{2}\right)}$

47. During combination 3.4 eV. After combination 3.84 eV, 2.64 eV.

48. (a) $4a/3$ (b) $a/\sqrt{3}$

IIT JEE 1998

IIT JEE 1998 has one physics paper of three hour duration.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper

The paper is divided into two parts, (A) and (B). The questions in part (A) has (i) objective questions with single option correct and (ii) objective questions with one or more option(s) correct. The questions in part (B) has descriptive questions. Total marks of the paper is 200 and there is no negative marking.

One Option Correct

This section is part (A) of the paper. The questions in this section has four options (A), (B), (C) and (D). Only one of these four options is correct. Each question is of two mark.

Q 1. A small square loop of wire of side l is placed inside a large square loop of wire of side L ($L \gg l$). The loops are coplanar and their centres coincide. The mutual inductance of the system is proportional to
(A) l/L (B) l^2/L (C) L/l (D) L^2/l

Q 2. A concave mirror is placed on a horizontal table with its axis directed vertically upwards. Let O be the pole of the mirror and C its center of curvature. A point object is placed at C. It has a real image, also located at C. If the mirror is now filled with water, the image will be

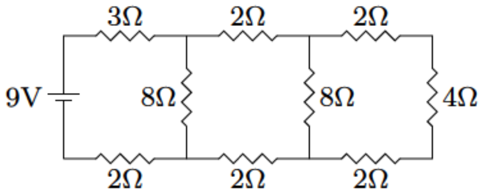
(A) real and will remain at C.
(B) real and located at a point between C and ∞.
(C) virtual and located at a point between C and O.
(D) real and located at a point between C and O.

Q 3. A spherical surface of radius of curvature R separates air (refractive index 1.0) from glass (refractive index 1.5). The centre of curvature is in the glass. A point object P placed in air is found to have a real image Q in the glass. The line PQ cuts the surface at a point O and PO = OQ. The distance PO is equal to
(A) $5R$ (B) $3R$ (C) $2R$ (D) $1.5R$

Q 4. A string of length 0.4 m and mass 10^{-2} kg is tightly clamped at its ends. The tension in the string is 1.6 N. Identical wave pulses are produced at one end at equal intervals of time Δt. The minimum value of Δt, which allows constructive interference between successive pulses is

(A) 0.05 s (B) 0.10 s (C) 0.20 s (D) 0.40 s

Q 5. In the circuit shown in the figure, the current through



(A) the 3 Ω resistor is 0.50 A
(B) the 3 Ω resistor is 0.25 A
(C) the 4 Ω resistor is 0.50 A
(D) the 4 Ω resistor is 0.25 A

Q 6. A charge $+q$ is fixed at each of the points $x = x_0$, $x = 3x_0$, $x = 5x_0$, $\cdots, \infty$ on the x-axis and a charge $-q$ is fixed at each of the points $x = 2x_0$, $x = 4x_0$, $x = 6x_0$, $\cdots, \infty$. Here x_0 is a positive constant. Take the electric potential at a point due to a charge Q at a distance r from it to be $Q/(4\pi\epsilon_0 r)$. Then, the potential at the origin due to the above system of charges is
(A) zero (B) $\frac{q}{8\pi\epsilon_0 x_0 \ln 2}$ (C) infinite (D) $\frac{q \ln 2}{4\pi\epsilon_0 x_0}$

Q 7. Two particles, each of mass m and charge q, are attached to the two ends of a light rigid rod of length $2R$. The rod is rotated at constant angular speed about a perpendicular axis passing through its centre. The ratio of the magnitudes of the magnetic moment of the system and its angular momentum about the centre of the rod is

(A) $q/(2m)$ (B) q/m (C) $2q/m$ (D) $q/(\pi m)$

Q 8. Two very long straight parallel wires carry steady currents I and $-I$ respectively. The distance between the wires is d. At a certain instant of time, a point charge q is at a point equidistant from the two wires in the plane of the wires. Its instantaneous velocity $\vec{v}$ is perpendicular to this plane. The magnitude of the force due to the magnetic field acting on the charge at this instant is

(A) $\frac{\mu_0 I q v}{2\pi d}$ (B) $\frac{\mu_0 I q v}{\pi d}$ (C) $\frac{2\mu_0 I q v}{\pi d}$ (D) zero

Q 9. A metal rod moves at a constant velocity in a direction perpendicular to its length. A constant uniform magnetic field exists in space in a direction perpendicular to the rod as well as its velocity. Select the correct statement(s) from the following,

(A) The entire rod is at the same electric potential.

(B) There is an electric field in the rod.

(C) The electric potential is highest at the centre of the rod and decrease towards its ends.

(D) The electric potential is lowest at the centre of the rod and increases towards its ends.

Q 10. In a p-n junction diode not connected to any circuit,

(A) the potential is same everywhere.

(B) the p-type side is at a higher potential than the n-type side.

(C) there is an electric field at the junction directed from the n-type side to the p-type side.

(D) there is an electric field at the junction directed from the p-type side to the n-type side.

Q 11. Water from a tap emerges vertically downwards with an initial speed of 1.0 m/s. The cross-sectional area of tap is 10^{-4} m^2. Assume that the pressure is constant throughout the stream of water and that the flow is steady. The cross-sectional area of stream 0.15 m below the tap is

(A) 5.0×10^{-4} m^2 (B) 1.0×10^{-4} m^2
(C) 5.0×10^{-5} m^2 (D) 2.0×10^{-5} m^2

Q 12. A given quantity of an ideal gas is at pressure p and absolute temperature T. The isothermal bulk modulus of the gas is
(A) $\frac{2}{3}p$ (B) p (C) $\frac{3}{2}p$ (D) $2p$

Q 13. A particle of mass m is executing oscillations about the origin on the x-axis. Its potential energy is $U(x) = k|x|^3$, where k is a positive constant. If the amplitude of oscillation is a, then its time period T is

(A) proportional to $1/\sqrt{a}$ (B) independent of a

(C) proportional to $\sqrt{a}$ (D) proportional to $a^{3/2}$

Q 14. A satellite S is moving in an elliptical orbit around the earth. The mass of the satellite is very small compared to the mass of the earth,

(A) the acceleration of S is always directed towards centre of the earth.

(B) the angular momentum of S about the centre of the earth changes in direction, but its magnitude remains constant.

(C) the total mechanical energy of S varies periodically with time.

(D) the linear momentum of S remains constant in magnitude.

Q 15. Let I be the moment of inertia of a uniform square plate about an axis AB that passes through its centre and is parallel to two of its sides. CD is a line in the plane of the plate that passes through the centre of the plate and makes an angle θ with AB. The moment of inertia of the plate about the axis CD is then equal to

(A) I (B) $I \sin^2 \theta$ (C) $I \cos^2 \theta$ (D) $I \cos^2 (\theta/2)$

Q 16. A stone tied to a string of length L is whirled in a vertical circle with the other end of the string at the centre. At a certain instant of time, the stone is at its lowest position, and has speed u. The magnitude of the change in its velocity as it reaches a position where the string is horizontal is

(A) $\sqrt{u^2 - 2gL}$ (B) $\sqrt{2gL}$
(C) $\sqrt{u^2 - gL}$ (D) $\sqrt{2(u^2 - gL)}$

Q 17. A force $\vec{F} = -k\,(y\hat{\imath} + x\hat{\jmath})$ (where k is a positive constant) acts on a particle moving in the x-y plane. Starting from the origin, the particle is taken along the positive x-axis to the point $(a, 0)$ and then parallel to the y-axis to the point (a, a). The total work done by the force F on the particle is

(A) $-2ka^2$ (B) $2ka^2$ (C) $-ka^2$ (D) ka^2

Q 18. A real image of a distant object is formed by a plano-convex lens on its principal axis. Spherical aberration

(A) is absent.

(B) is smaller if the curved surface of the lens faces the object.

(C) is smaller if the plane surface of the lens faces the object.

(D) is the same whichever side of the lens faces the object.

Q 19. A parallel monochromatic beam of light is incident normally on a narrow slit. A diffraction pattern is formed on a screen placed perpendicular to the direction of the incident beam. At the first minimum of the diffraction pattern, the phase difference between the rays coming from the two edges of the slit is
(A) zero (B) $\pi/2$ (C) π (D) 2π

Q 20. The half life of ^{131}I is 8 days. Given a sample of ^{131}I at time $t = 0$, we can assert that

(A) no nucleus will decay before $t = 4$ days.

(B) no nucleus will decay before $t = 8$ days.

(C) all nuclei will decay before $t = 16$ days.

(D) a given nucleus may decay at any time after $t = 0$.

Q 21. X-rays are produced in an X-ray tube operating at a given accelerating voltage. The wavelength of the continuous X-rays has values from

(A) 0 to ∞.

(B) λ_{min} to ∞, where $\lambda_{\text{min}} > 0$.

(C) 0 to λ_{max}, where $\lambda_{\text{max}} < \infty$.

(D) λ_{min} to λ_{max} where $0 < \lambda_{\text{min}} < \lambda_{\text{max}} < \infty$.

Q 22. The work function of a substance is 4 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately
(A) 540 nm (B) 400 nm (C) 310 nm (D) 220 nm

Q 23. A vessel contains a mixture of 1 mol of O_2 and 2 mol of N_2 at 300 K. The ratio of the average rotational kinetic energy per O_2 molecule to that of per N_2 molecule is

(A) 1 : 1
(B) 1 : 2
(C) 2 : 1
(D) depends on the moment of inertia of the molecules.

Q 24. Two identical containers A and B with frictionless pistons contain the same ideal gas at the same temperature and the same volume V. The mass of the gas in A is m_A and that in B is m_B. The gas in each cylinder is now allowed to expand isothermally to the same final volume $2V$. The changes in the pressure in A and B are found to be Δp and $1.5\Delta p$, respectively. Then,

(A) $4m_A = 9m_B$ (B) $2m_A = 3m_B$

(C) $3m_A = 2m_B$ (D) $9m_A = 4m_B$

Q 25. Two cylinders A and B fitted with pistons contain equal amounts of an ideal diatomic gas at 300 K. The piston of A is free to move, while that of B is held fixed. The same amount of heat is given to the gas in each cylinder. If the rise in temperature of the gas in A is 30 K, then the rise in temperature of the gas in B is

(A) 30 K (B) 18 K (C) 50 K (D) 42 K

Q 26. A black body is at a temperature of 2880 K. The energy of radiation emitted by this body with wavelength between 499 nm and 500 nm is U_1, between 999 nm and 1000 nm is U_2 and between 1499 nm and 1500 nm is U_3. [The Wien constant, $b = 2.88 \times 10^6$ nm K]. Then,

(A) $U_1 = 0$ (B) $U_3 = 0$ (C) $U_1 > U_2$ (D) $U_2 > U_1$

One or More Option(s) Correct

This section is also part (A) of the paper. The questions in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 27. The SI unit of the inductance, the Henry can be written as

(A) weber/ampere (B) volt-second/ampere

(C) joule/$(\text{ampere})^2$ (D) ohm-second

Q 28. Let $[\epsilon_0]$ denotes the dimensional formula of the permittivity of the vacuum and $[\mu_0]$ that of the permeability of the vacuum. If M = mass, L = length, T = time and I = electric current, then

(A) $[\epsilon_0] = [\mathrm{M^{-1}L^{-3}T^2I}]$ (B) $[\epsilon_0] = [\mathrm{M^{-1}L^{-3}T^4I^2}]$

(C) $[\mu_0] = [\mathrm{MLT^{-2}I^{-2}}]$ (D) $[\mu_0] = [\mathrm{ML^2T^{-1}I}]$

Q 29. The torque $\vec{\tau}$ on a body about a given point is found to be equal to $\vec{A} \times \vec{L}$, where $\vec{A}$ is a constant vector and $\vec{L}$ is the angular momentum of the body about that point. From this its follows that,

(A) $\frac{d\vec{L}}{dt}$ is perpendicular to $\vec{L}$ at all instants of time.

(B) the component of $\vec{L}$ in the direction of $\vec{A}$ does not change with time.

(C) the magnitude of $\vec{L}$ does not change with time.

(D) $\vec{L}$ does not change with time.

Q 30. A transistor is used in common emitter mode as an amplifier, then

(A) the base emitter junction is forward biased.

(B) the base emitter junction is reversed biased.

(C) the input signal is connected in series with the voltage applied to bias the base-emitter junction.

(D) the input signal is connected in series with the voltage applied to bias the base-collector junction.

Q 31. Let m_p be the mass of proton, m_n the mass of neutron, M_1 the mass of ${}^{20}_{10}\text{Ne}$ nucleus and M_2 the mass of ${}^{40}_{20}\text{Ca}$ nucleus. Then,

(A) $M_2 = 2M_1$ (B) $M_2 > 2M_1$

(C) $M_2 < 2M_1$ (D) $M_1 < 10(m_n + m_p)$

Q 32. The electron in a hydrogen atom makes a transition $n_1 \to n_2$, where n_1 and n_2 are the principal quantum numbers of two states. Assume the Bohr's model to be valid. The time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are

(A) $n_1 = 4, n_2 = 2$ (B) $n_1 = 8, n_2 = 2$

(C) $n_1 = 8, n_2 = 1$ (D) $n_1 = 6, n_2 = 3$

Q 33. A positively charged thin metal ring of radius R is fixed in the x-y plane with its centre at the origin O. A negatively charged particle P is released from rest at the point $(0, 0, z_0)$ where $z_0 > 0$. Then the motion of P is

(A) periodic for all values of z_0 satisfying $0 < z_0 < \infty$.

(B) simple harmonic for all values of z_0 satisfying $0 < z_0 \leq R$.

(C) approximately simple harmonic provided $z_0 \ll R$.

(D) such that P crosses O and continues to move along the negative z axis towards $z = -\infty$.

Q 34. A dielectric slab of thickness d is inserted in a parallel plate capacitor whose negative plate is at $x = 0$ and positive plate is at $x = 3d$. The slab is equidistant from the plates. The capacitor is given some charge. As x goes from 0 to $3d$,

(A) the magnitude of the electric field remains the same.

(B) the direction of the electric field remains the same.

(C) the electric potential increases continuously.

(D) the electric potential increases at first, then decreases and again increases.

Q 35. A ray of light travelling in a transparent medium falls on a surface separating the medium from air at an angle of incidence 45°. The ray undergoes total internal reflection. If n is the refractive index of the medium with respect to air, select the possible value(s) of n from the following,
(A) 1.3 (B) 1.4 (C) 1.5 (D) 1.6

Q 36. Let $\bar{v}$, v_{rms} and v_{p} respectively denote the mean speed, root mean square speed and most probable speed of the molecules in an ideal monatomic gas at absolute temperature T. The mass of the molecule is m. Then,

(A) no molecule can have speed greater than $\sqrt{2}v_{\mathrm{rms}}$.
(B) no molecule can have speed less than $v_{\mathrm{p}}/\sqrt{2}$.
(C) $v_{\mathrm{p}} < \bar{v} < v_{\mathrm{rms}}$.
(D) the average kinetic energy of a molecule is $\frac{3}{4}mv_{\mathrm{p}}^2$.

Q 37. During the melting of slab of ice at 273 K at atmospheric pressure,

(A) positive work is done by the ice-water system on the atmosphere.

(B) positive work is done on the ice-water system by the atmosphere.

(C) the internal energy of the ice-water system increases.

(D) the internal energy of the ice-water system decreases.

Q 38. A non-conducting solid sphere of radius R is uniformly charged. The magnitude of the electric field due to the sphere, at a distance r from its centre,

(A) increases as r increases for $r < R$.
(B) decreases as r increases for $0 < r < \infty$.
(C) decreases as r increases for $R < r < \infty$.
(D) is discontinuous at $r = R$.

Q 39. A transverse sinusoidal wave of amplitude a, wavelength λ and frequency f is travelling on a stretched string. The maximum speed of any point on the string is $v/10$, where v is the speed of propagation of the wave. If $a = 10^{-3}$ m and $v = 10$ m/s, then λ and f are given by

(A) $\lambda = 2\pi \times 10^{-2}$ m (B) $\lambda = 10^{-3}$ m

(C) $f = \frac{10^3}{2\pi}$ Hz (D) $f = 10^4$ Hz

Q 40. The (x, y) coordinates of the corners of a square plate are $(0, 0)$, $(L, 0)$, (L, L), and $(0, L)$. The edges of the plate are clamped and transverse standing waves are set-up in it. If $u(x, y)$ denotes the displacement of the plate at the point (x, y) at some instant of time, the possible expression(s) for u is (are) [Where a is a positive constant.]

(A) $a \cos\frac{\pi x}{2L} \cos\frac{\pi y}{2L}$ (B) $a \sin\frac{\pi x}{L} \sin\frac{\pi y}{L}$

(C) $a \sin\frac{\pi x}{L} \sin\frac{2\pi y}{L}$ (D) $a \cos\frac{2\pi x}{L} \sin\frac{\pi y}{L}$

Descriptive

This section is part (B) of the paper. There are 15 descriptive questions in this section. Each question is of 8 marks.

Q 41. The air column in a pipe closed at one end is made to vibrate in its second overtone by a tuning fork of frequency 440 Hz. The speed of sound in air is 330 m/s. End corrections may be neglected. Let p_0 denote the mean pressure at any point in the pipe and Δp_0 the maximum amplitude of pressure variation.

(a) Find the length L of air column.

(b) What is the amplitude of pressure variation at the middle of the column?

(c) What are the maximum and minimum pressures at the open end of the pipe?

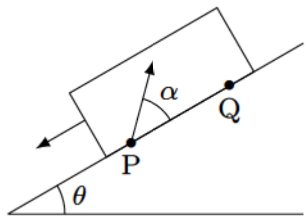
(d) What are the maximum and minimum pressures at the close end of the pipe?

Q 42. A solid body X of heat capacity C is kept in an atmosphere whose temperature is $T_A = 300$ K. At time $t = 0$, the temperature of X is $T_0 = 400$ K. It cools according to Newton's law of cooling. At time t_1 its temperature is found to be 350 K. At this time (t_1) the body X is connected to a large body Y at atmospheric temperature T_A through a conducting rod of length L, cross-sectional area A and thermal conductivity K. The heat capacity of Y is so large that any variation in its temperature may be neglected. The cross-sectional area A of the connecting rod is small compared to the surface area of X. Find the temperature of X at time $t = 3t_1$.

Q 43. A large heavy box is sliding without friction down a smooth plane of inclination θ. From a point P on the bottom of the box, a particle is projected inside the box. The initial speed of the particle with respect to the box is u and the direction of projection makes an angle α with the bottom as shown in the figure.

(a) Find the distance along the bottom of the box between the point of projection P and the point Q where the particle lands. [Assume that the particle does not hit any other surface of the box. Neglect air resistance.]

(b) If the horizontal displacement of the particle as seen by an observer on the ground is zero, find the speed of the box with respect to the ground at the instant when the particle was projected.

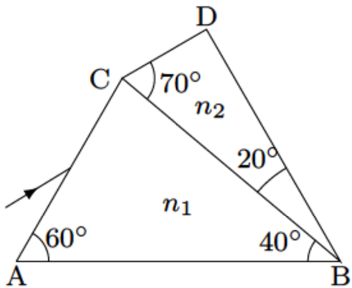


Q 44. A particle of mass 10^{-2} kg is moving along the positive x-axis under the influence of force $F(x) = -\frac{k}{2x^2}$, where $k = 10^{-2}$ N m^2. At time $t = 0$ it is at $x = 1.0$ m and its velocity $v = 0$.

(a) Find its velocity when it reaches $x = 0.5$ m.

(b) Find the time at which it reaches $x = 0.25$ m.

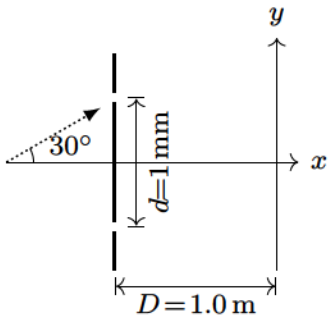
Q 45. A prism of refractive index n_1 and another prism of refractive index n_2 are stuck together with gap as shown in the figure. The angles of the prism are as shown. The n_1 and n_2 depends on λ, the wavelength of light, according to: $n_1 = 1.20 + \frac{10.8\times10^4}{\lambda^2}$ and $n_2 = 1.45 + \frac{1.80\times10^4}{\lambda^2}$, where λ is in nm.



(a) Calculate the wavelength λ_0 for which rays incident at any angle on the interface BC pass through without bending at that interface.

(b) For light of wavelength λ_0, find the angle of incidence i on the face AC such that the deviation produced by the combination of prisms is minimum.

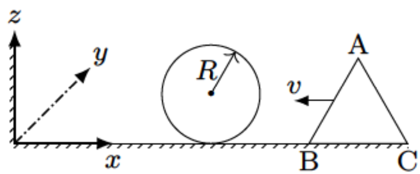
Q 46. A coherent parallel beam of microwaves of wavelength $\lambda = 0.5$ mm falls on a Young's double slit apparatus. The separation between the slits is 1.0 mm. The intensity of microwaves is measured on a screen placed parallel to the plane of the slits at a distance of 1.0 m from it as shown in the figure.



(a) If the incident beam falls normally on the double slit apparatus, find the y-coordinates of all the interference minima on the screen.

(b) If the incident beam makes an angle of 30° with the x-axis (as in the dotted arrow shown in figure), find the y-coordinates of the first minima on either side of the central maximum.

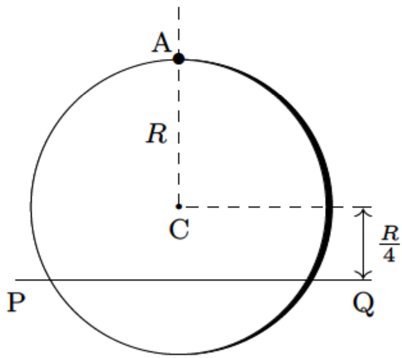
Q 47. A wedge of mass m and triangular cross-section (AB = BC = CA = $2R$) is moving with a constant velocity $(-v\hat{\imath})$ towards a sphere of radius R fixed on a smooth horizontal table as shown in the figure. The wedge makes an elastic collision with the fixed sphere and returns along the same path without any rotation. Neglect all friction and suppose that the wedge remains in contact with the sphere for a very short time Δt, during which the sphere exerts a constant force $\vec{F}$ on the wedge.



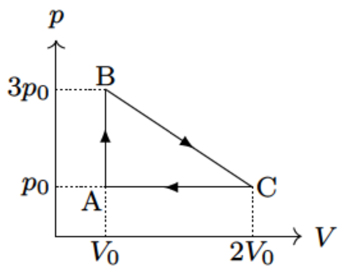
(a) Find the force $\vec{F}$ and also the normal force $\vec{N}$ exerted by the table on the wedge during the time Δt.

(b) Let h denote the perpendicular distance between the centre of mass of the wedge and the line of action of $\vec{F}$. Find the magnitude of the torque due to the normal force $\vec{N}$ about the centre of the wedge, during the interval Δt.

Q 48. A uniform circular disc has radius R and mass m. A particle, also of mass m, is fixed at a point A on the edge of the disc as shown in the figure. The disc can rotate freely about a horizontal chord PQ that is at a distance $R/4$ from the centre C of the disc. The line AC is perpendicular to PQ. Initially the disc is held vertical with the point A at its highest position. It is then allowed to fall, so that it starts rotation about PQ. Find the linear speed of the particle as it reaches its lowest position.



Q 49. One mole of an ideal monatomic gas is taken round the cyclic process ABCA as shown in the figure. Calculate,



(a) the work done by the gas.
(b) the heat rejected by the gas in the path CA and the heat absorbed by the gas in the path AB.
(c) the net heat absorbed by the gas in the path BC.
(d) the maximum temperature attained by the gas during the cycle.

Q 50. Nuclei of radioactive element A are being produced at a constant rate α. The element has a decay constant λ. At time $t = 0$, there are N_0 nuclei of the element.

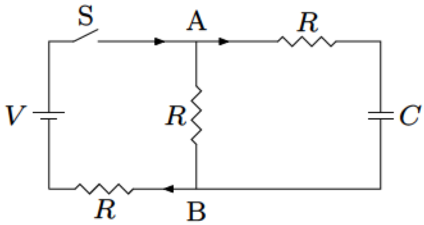
(a) Calculate the number N of nuclei of A at time t.

(b) If $\alpha = 2N_0\lambda$, calculate the number of nuclei of A after one half-life of A and also the limiting value of N as $t \to \infty$.

Q 51. An inductor of inductance 2.0 mH is connected across a charged capacitor of capacitance 5.0 μF and the resulting L-C circuit is set oscillating at its natural frequency. Let Q denotes the instantaneous charge on the capacitor and I the current in the circuit. It is found that the maximum value of Q is 200 μC.

(a) When $Q = 100$ μC, what is the value of $|\frac{\mathrm{d}I}{\mathrm{d}t}|$?
(b) When $Q = 200$ μC, what is the value of I?
(c) Find the maximum value of I.
(d) When I is equal to one-half of its maximum value, what is the value of $|Q|$?

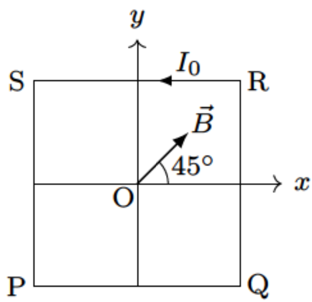
Q 52. In the circuit shown in figure, the battery is an ideal one, with *emf* V. The capacitor is initially uncharged. The switch S is closed at time $t = 0$. Find,



(a) the charge q on the capacitor at time t.

(b) the current in AB at time t. What is its limiting value as $t \to \infty$?

Q 53. A uniform constant magnetic field $\vec{B}$ is directed at an angle of 45° to the x-axis in x-y plane. PQRS is rigid square wire frame carrying a steady current I_0, with its centre at the origin O. At time $t = 0$, the frame is at rest in the position shown in the figure with its sides parallel to x and y-axes. Each side of the frame is of mass M and length L.



(a) What is the torque $\vec{\tau}$ acting on the frame due to the magnetic field?

(b) Find the angle by which the frame rotates under the action of this torque in a short interval of time Δt and the axis about which this rotation occurs (Δt is so short that any variation in the torque during this interval may be neglected). [Given: the moment of inertia of the frame about an axis through its centre perpendicular to its plane is $\frac{4}{3}ML^2$.]

Q 54. A particle of mass m and charge q is moving in a region where uniform constant electric and magnetic fields $\vec{E}$ and $\vec{B}$ are present. $\vec{E}$ and $\vec{B}$ are parallel to each other. At time $t = 0$, the velocity $\vec{v}_0$ of the particle is perpendicular to $\vec{E}$ (assume that its speed is always $\ll c$, the speed of light in vacuum). Find the velocity $\vec{v}$ of the particle at time t. You must express your answer in terms of t, q, m, the vector $\vec{v}_0$, $\vec{E}$ and $\vec{B}$ and their magnitude v_0, E and B.

Q 55. A conducting sphere S_1 of radius r is attached to an insulating handle. Another conducting sphere S_2 of radius R is mounted on an insulating stand. S_2 is initially uncharged. S_1 is given a charge Q, brought into contact with S_2 and removed. S_1 is recharged such that the charge on it is again Q and it is again brought into contact with S_2 and removed. This procedure is repeated n times.

(a) Find the electrostatic energy of S_2 after n such contacts with S_1.

(b) What is the limiting value of this energy as $n \to \infty$?

Answers

1. B
2. D
3. A
4. B
5. D
6. D
7. A
8. D
9. B
10. C
11. C
12. B
13. A
14. A
15. A
16. D
17. C
18. B
19. D
20. D
21. B
22. C
23. A
24. C
25. D
26. D
27. A, B, C, D
28. B, C
29. A, B, C
30. A, C
31. C, D
32. A, D
33. A, C
34. B, C
35. C, D
36. C, D
37. B, C
38. A, C
39. A, C
40. B, C
41. (a) $\frac{15}{16}$ m (b) $\pm\frac{\Delta p_0}{\sqrt{2}}$
(c) $p_{\text{max}} = p_{\text{min}} = p_0$
(d) $p_0 + \Delta p_0$, $p_0 - \Delta p_0$
42. $\left(300 + 12.5e^{-\frac{2KAt_1}{CL}}\right)$ K
43. (a) $\frac{u^2 \sin 2\alpha}{g\cos\theta}$ (b) $\frac{u\cos(\alpha+\theta}{\cos\theta}$
44. (a) -1.0 m/s
(b) 1.48 s
45. (a) 600 nm (b) $\sin^{-1}\left(\frac{3}{4}\right.$

46. (a) $\pm 1/\sqrt{15}$ m, $\pm 3/\sqrt{7}$ m (b) $1/\sqrt{15}$ m, $3/\sqrt{7}$ m

47. (a) $\frac{2mv}{\sqrt{3}\Delta t}\left(\sqrt{3}\hat{\imath} - \hat{k}\right)$, $\left(\frac{2mv}{\sqrt{3}\Delta t} + mg\right)\hat{k}$
(b) $\frac{4mv}{\sqrt{3}\Delta t}h$

48. $\sqrt{5gR}$

49. (a) p_0V_0 (b) $5p_0V_0/2$, $3p_0V_0$ (c) $p_0V_0/2$
(d) $25p_0V_0/(8R)$

50. (a) $\frac{1}{\lambda}\left[\alpha - (\alpha - \lambda N_0)e^{-\lambda t}\right]$
(b) (i) $3N_0/2$ (ii) $2N_0$

51. (a) 10^4 A/s (b) zero (c) 2.0 A (d) 1.732×10

52. (a) $\frac{CV}{2}\left[1 - e^{-\frac{2t}{3RC}}\right]$
(b) $\frac{V}{2R} - \frac{V}{6R}e^{-\frac{2t}{3RC}}$, $\frac{V}{2R}$

53. (a) $\frac{I_0L^2B}{\sqrt{2}}\left(\hat{\jmath} - \hat{\imath}\right)$
(b) $\frac{3}{4}\frac{I_0B}{M}(\Delta t)^2$

54. $\cos\left(\frac{qBt}{m}\right)\vec{v}_0 + \frac{qt}{m}\vec{E} + \sin\left(\frac{qBt}{m}\right)\left(\frac{\vec{v}_0 \times \vec{B}}{B}\right)$

55. (a) $U_n = \frac{Q^2R}{8\pi\epsilon_0 r^2}\left[1 - \left(\frac{}{R}\right.\right.$
(b) $U_\infty = \frac{Q^2R}{8\pi\epsilon_0 r^2}$

IIT JEE 1997

IIT JEE 1997 was conducted twice because of paper leak. There is one physics paper of three hour duration. We call these papers as Paper and Paper (Cancelled). The format is similar for both papers.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper

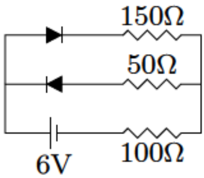
There are three types of questions (i) objective questions with single option correct (ii) fill in the blanks type and (iii) descriptive type. Total marks of the paper is 100 and there is no negative marking.

Note: The paper has 16 questions. One of these questions has 9 parts of type (i) and another question has 11 parts of type (ii). Remaining questions are of descriptive type.

One Option Correct

There are 9 questions in this section. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Each question is of one mark.

Q 1. The circuit shown in the figure contains two diodes each with a forward resistance of 50 Ω and with infinite backward resistance. If the battery voltage is 6 V, the current through the 100 Ω resistance is



(A) zero (B) 0.02 A (C) 0.03 A (D) 0.036 A

Q 2. A proton, a deuteron and an α-particle having the same kinetic energy are moving in circular trajectories in a constant magnetic field. If r_p, r_d and r_α denote respectively the radii of the trajectories of these particles, then

(A) $r_\alpha = r_p < r_d$ (B) $r_\alpha > r_d > r_p$

(C) $r_\alpha = r_d > r_p$ (D) $r_p = r_d = r_\alpha$

Q 3. A travelling wave in a stretched string is described by the equation: $y = A\sin(kx - \omega t)$. The maximum particle velocity is
(A) $A\omega$ (B) ω/k (C) $\mathrm{d}\omega/\mathrm{d}k$ (D) x/ω

Q 4. A spherical black body with a radius of 12 cm radiates 450 W power at 500 K. If the radius were halved and the temperature doubled, the power radiated (in W) would be
(A) 225 (B) 450 (C) 900 (D) 1800

Q 5. A vessel contains 1 mol of O_2 gas (molar mass 32) at a temperature T. The pressure of the gas is p. An identical vessel containing one mole of the gas (molar mass 4) at a temperature $2T$ has a pressure of

(A) $p/8$ (B) p (C) $2p$ (D) $8p$

Q 6. The average translational kinetic energy of O_2 (molar mass 32) molecules at a particular temperature is 0.048 eV. The translational kinetic energy of N_2 (molar mass 28) molecules (in eV) at the same temperature is

(A) 0.0015 (B) 0.003 (C) 0.048 (D) 0.768

Q 7. The maximum kinetic energy of photoelectrons emitted from a surface when photons of energy 6 eV falls on it is 4 eV. The stopping potential is
(A) 2 V (B) 4 V (C) 6 V (D) 10 V

Q 8. As per Bohr model, the minimum energy required to remove an electron from the ground state of doubly ionized Li atom ($Z = 3$) is
(A) 1.51 eV (B) 13.6 eV (C) 40.8 eV (D) 122.4 eV

Q 9. Which of the following is not true?

(A) The resistance of intrinsic semiconductors decreases with increase of temperature.

(B) Doping pure Si with trivalent impurities gives p-type semiconductors.

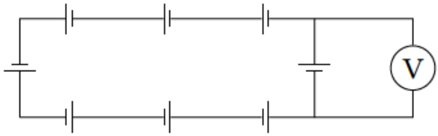
(C) The majority carriers in n-type semiconductors are holes.

(D) The p-n junction can act as a semiconductor diode.

Fill in the Blank Type

There are 11 fill in the blank(s) type questions in this section. Each question is of two marks.

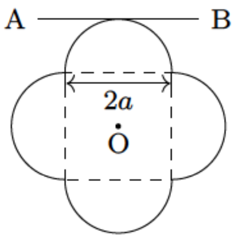
Q 10. In the given circuit, each battery is 5 V and has an internal resistance of 0.2 Ω. The reading in the ideal voltmeter V is ...... V.



Q 11. The earth receives 1400 W/m^2 of solar power. If all the solar energy falling on a lens of area 0.2 m^2 is focused onto a block of ice of mass 280 g, the time taken to melt the ice will be ...... minutes. [Latent heat of fusion of ice $= 3.3 \times 10^5$ J/kg.]

Q 12. The equation of state of a real gas is given by $\left(p + \frac{a}{V^2}\right)(V - b) = RT$, where p, V and T are pressure, volume and temperature respectively and R is the universal gas constant. The dimensions of the constant a in this equation is ......

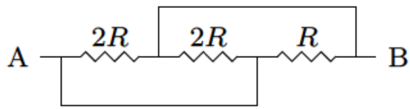
Q 13. A symmetric lamina of mass M consists of a square shape with a semicircular section over each of the edge of the square as shown in the figure. The side of the square is $2a$. The moment of inertia of the lamina about an axis through its centre of mass and perpendicular to the plane is $1.6Ma^2$. The moment of inertia of the lamina about the tangent AB in the plane of the lamina is ......



Q 14. A rod of weight W is supported by two parallel knife edges A and B and is in equilibrium in a horizontal position. The knives are at a distance d from each other. The centre of mass of the rod is at distance x from A. The normal reaction on A is ...... and on B is ......

Q 15. A particle is projected vertically upwards from the surface of earth (radius R) with a kinetic energy equal to half of the minimum value needed for it to escape. The height to which it rises above the surface of earth is ......

Q 16. The equivalent resistance between points A and B of the given circuit is ......

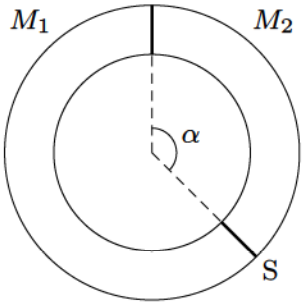


Q 17. A ray of light is incident normally on one of the faces of a prism of apex angle 30° and refractive index $\sqrt{2}$. The angle of deviation of the ray is $\ldots\ldots^\circ$.

Q 18. Two thin lenses, when in contact, produce a combination of power $+10\,D$. When they are 0.25 m apart, the power reduces to $+6\,D$. The focal length of the lenses are ...... m and ...... m.

Q 19. A monochromatic beam of light of wavelength 6000 Å in vacuum enters a medium of refractive index 1.5. In the medium its wavelength is ...... and its frequency is ......

Q 20. A ring shaped tube contains two ideal gases with equal masses and relative molar masses $M_1 = 32$ and $M_2 = 28$. The gases are separated by one fixed partition and another movable stopper S which can move freely without friction inside the ring. The angle α as shown in the figure is ......$^\circ$.



Descriptive

There are 14 decriptive questions in this section.

Q 21. The element curium $^{248}_{96}\text{Cm}$ has a mean life of 10^{13} s. Its primary decay modes are spontaneous fission and α-decay, the former with a probability of 8% and the latter with a probability of 92%, each fission releases 200 MeV of energy. The masses involved in decay are $^{248}_{96}\text{Cm} = 248.072220$ u, $^{244}_{94}\text{Pu} = 244.064100$ u, $^{4}_{2}\text{He} = 4.002603$ u. Calculate the power output from a sample of 10^{20} Cm atoms. [1 u=931 MeV/c^2.]

Q 22. In a Young's double slit experiment, the upper slit is covered by a thin glass plate of refractive index 1.4, while the lower slit is covered by another glass plate, having the same thickness as the first one but having refractive index 1.7. Interference pattern is observed using light of wavelength 5400 Å. It is found that the point P on the screen, where the central maximum ($n = 0$) falls before the glass plates were inserted, now has 3/4 the original intensity. It is further observed that what used to be the fifth maximum earlier lies below the point P while the sixth minima lies above P. Calculate the thickness of glass plate. [Absorption of light by glass plate may be neglected.]

Q 23. Assume that the de-Broglie wave associated with an electron can form a standing wave between the atoms arranged in a one dimensional array with nodes at each of the atomic sites. It is found that one such standing wave is formed if the distance d between the atoms of the array is 2 Å. A similar standing wave is again formed if d is increased to 2.5 Å but not for any intermediate value of d. Find the energy of the electron (in eV) and the least value of d for which the standing wave of the type described above can form.

Q 24. A cart is moving along x direction with a velocity of 4 m/s. A person on the cart throws a stone with a velocity of 6 m/s relative to himself. In the frame of reference of the cart, the stone is thrown in y-z plane making an angle of 30° with vertical z-axis. At the highest point of its trajectory the stone hits an object of equal mass hung vertically from branch of a tree by means of a string of length L. A completely inelastic collision occurs, in which the stone gets embedded in the object. Determine, [Take $g = 9.8\ \mathrm{m/s^2}$.]

(a) the speed of the combined mass immediately after the collision with respect to an observer on the ground.

(b) the length L of the string such that tension in the string becomes zero when the string becomes horizontal during the subsequent motion of the combined mass.

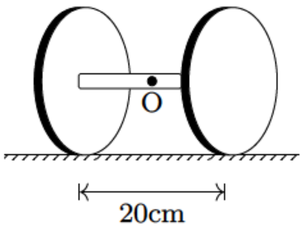
Q 25. Two blocks of mass $m_1 = 10$ kg and $m_2 = 5$ kg connected to each other by a massless inextensible string of length 0.3 m are placed along a diameter of turn table. The coefficient of friction between the table and m_1 is 0.5 while there is no friction between m_2 and the table. The table is rotating with an angular velocity of 10 rad/s about a vertical axis passing through its centre O. The masses are placed along the diameter of table on either side of the centre O such that the mass m_1 is at a distance of 0.124 m from O. The masses are observed to be at rest with respect to an observer on the turn table.

(a) Calculate the frictional force on m_1.

(b) What should be the minimum angular speed of the turn table, so that the masses will slip from this position?

(c) How should the masses be placed with the string remaining taut so that there is no frictional force acting on the mass m_1?

Q 26. Two thin circular discs of mass 2 kg and radius 10 cm each are joined by a rigid massless rod of length 20 cm. The axis of the rod is along the perpendicular to the planes of the disc through their centres. The object is kept on a truck in such a way that the axis of the object is horizontal and perpendicular to the direction of motion of the truck. Its friction with the floor of the truck is large enough, so that the object can roll on the truck without slipping. Take x-axis as the direction of motion of the truck and z-axis as the vertically upwards direction. If the truck has an acceleration 9 m/s^2, calculate,

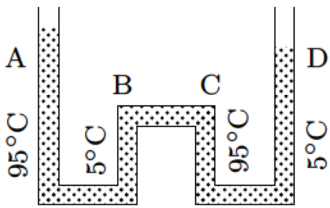


(a) the force of friction on each disc.

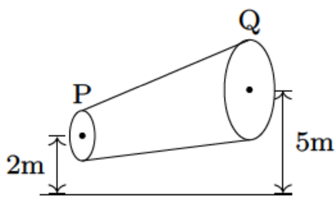
(b) the magnitude and direction of the frictional torque acting on each disc about the centre of mass O of the object. Express the torque in the vector form in terms of vector $\hat{\imath}$, $\hat{\jmath}$ and $\hat{k}$ in x, y and z directions.

Q 27. One mole of a diatomic gas ($\gamma = 1.4$) is taken through a cyclic process starting from A. The process $A \rightarrow B$ is an adiabatic compression, $B \rightarrow C$ is isobaric expansion, $C \rightarrow D$ an adiabatic expansion and $D \rightarrow A$ is isochoric. The volume ratio are $V_A/V_B = 16$ and $V_C/V_B = 2$ and the temperature at A is $T_A = 300\,\mathrm{K}$. Calculate the temperature of the gas at the points B and D and find the efficiency of the cycle.

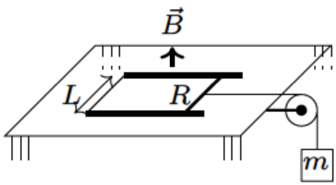
Q 28. The apparatus shown in the figure consists of four glass columns connected by horizontal sections. The height of two central columns B and C are 49 cm each. The two outer columns A and D are open to the atmosphere. A and C are maintained at a temperature of 95 °C while the column B and D are maintained at 5 °C. The height of the liquid in A and D measured from the base line are 52.8 cm and 51 cm respectively. Determine the linear coefficient of thermal expansion of the liquid.



Q 29. A non-viscous liquid of constant density $1000\ \mathrm{kg/m^3}$ flows in streamline motion along a tube of variable cross-section. The tube is kept inclined in the vertical plane as shown in the figure. The area of cross-section of the tube at two points P and Q at heights of $2\ \mathrm{m}$ and $5\ \mathrm{m}$ are respectively $4 \times 10^{-3}\ \mathrm{m^2}$ and $8 \times 10^{-3}\ \mathrm{m^2}$. The velocity of the liquid at point P is $1\ \mathrm{m/s}$. Find the work done per unit volume by the pressure and the gravity forces as the fluid flows from point P to Q.



Q 30. A pair of parallel horizontal conducting rails of negligible resistance shorted at one end is fixed on a table. The distance between the rails is L. A conducting massless rod of resistance R can slide on the rails frictionlessly. The rod is tied to a massless string which passes over a pulley fixed to the edge of the table. A mass m tied to the other end of the string hangs vertically. A constant magnetic field B exists perpendicular to the table. If the system is released from rest, calculate,



(a) the terminal velocity achieved by the rod.

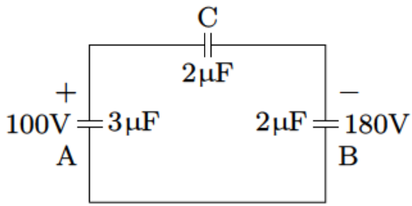
(b) the acceleration of the mass at the instant when the velocity of the rod is half the terminal velocity.

Q 31. Three infinitely long thin wires, each carrying current i in the same direction, are in the x-y plane of a gravity free space. The central wire is along the y-axis while the other two are along $x = \pm d$.

(a) Find the locus of the points for which the magnetic field B is zero.

(b) If the central wire is displaced along the z direction by a small amount and released, show that it will execute SHM. If the linear density of the wires is λ, find the frequency of oscillation.

Q 32. Two capacitors A and B with capacities 3 μF and 2 μF are charged to a potential difference of 100 V and 180 V respectively. The plates of the capacitors are connected as shown in the figure with one wire of each capacitor free. The upper plate of A is positive and that of B is negative. An uncharged 2 μF capacitor C with lead wires falls on the free ends to complete the circuit. Calculate,



(a) the final charge on the three capacitors.

(b) the amount of electrostatic energy stored in the system before and after completion of the circuit.

Q 33. In the following, *Column I* lists some physical quantities and the *Column II* gives approximate energy values associated with some of them. Choose the appropriate value of energy from *Column II* for each of the physical quantities in *Column I*.

Column I	Column II
(A) Energy of thermal neutrons	(p) 0.025 eV
(B) Energy of X-rays	(q) 0.5 eV
(C) Binding energy per nucleon	(r) 3 eV
(D) Photoelectric threshold of a metal	(s) 20 eV
	(t) 8 MeV
	(u) 10 keV

Q 34. A band playing music at a frequency f is moving towards a wall at a speed v_b. A motorist is following the band with a speed v_m. If v is the speed of sound, obtain an expression for the beat frequency heard by the motorist.

Answers

1. B
2. A
3. A
4. D
5. C
6. C
7. B
8. D
9. C
10. zero
11. 5.5
12. [ML^5T^{-2}]
13. $4.8Ma^2$
14. $W(d-x)/d$, Wx/d
15. R
16. $R/2$
17. 15°
18. $0.125, 0.5$
19. 4000 Å, 5×10^{14} Hz
20. 192
21. 3.32×10^{-5} W
22. 9.3 μm
23. 151 eV (b) 0.5 Å
24. (a) 2.5 m/s (b) 0.32 m
25. (a) 36 N (b) 11.67 rad/s (c) 0.1 m, 0.2 m
26. (a) $6\hat{\imath}$ N, (b) $(-0.6\hat{\jmath}+0.6\hat{k})$ N m, $(-0.6\hat{\jmath}-0.6\hat{k})$ N m, 0.85 N m
27. $T_B = 909$ K, $T_D = 791.4$ K, $\eta = 61.4\%$
28. 6.7×10^{-5} /°C
29. 29025 J/m^3, −29400 J/
30. (a) $\frac{mgR}{B^2L^2}$ (b) $g/2$
31. (a) $(x = 0, \pm\frac{d}{\sqrt{3}}, z = 0)$ (b) $\frac{i}{2\pi d}\sqrt{\frac{\mu_0}{\pi\lambda}}$
32. (a) $q_A = 90$ μC, $q_B = 150$ μC, $q_C = 210$ μC (b) $U_i = 47.4$ mJ, $U_f = 18$ mJ
33. A↦p, B↦u, C↦t, D↦r
34. $\frac{2v_b(v+v_m)}{v^2-v_b^2}f$

Paper (Cancelled)

There are three types of questions (i) objective questions with single option correct (ii) fill in the blanks type and (iii) descriptive type. Total marks of the paper is 100 and there is no negative marking.

Note: The paper has 15 questions. One question has 15 parts of type (i) and another question has 10 parts of type (ii). Remaining questions are of descriptive types, some of them have multiple parts.

One Option Correct

There are 15 questions in this section. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Each question is of one mark.

Q 1. The electrical conductivity of a semiconductor increases when electromagnetic radiation of wavelength shorter than 2480 nm is incident on it. The band gap (in eV) for the semiconductor is
(A) 0.9 (B) 0.7 (C) 0.5 (D) 1.1

Q 2. An artificial satellite moving in a circular orbit around the earth has a total (kinetic + potential) energy E_0. Its potential energy is
(A) $-E_0$ (B) $1.5E_0$ (C) $2E_0$ (D) E_0

Q 3. An isolated particle of mass m is moving in horizontal plane (x-y), along the x-axis, at a certain height above the ground. It suddenly explodes into two fragment of masses $m/4$ and $3m/4$. An instant later, the smaller fragment is at $y = 15$ cm. The larger fragment at this instant is at

(A) $y = -5$ cm (B) $y = 20$ cm

(C) $y = 5$ cm (D) $y = -20$ cm

Q 4. A mass m is moving with a constant velocity along a line parallel to the x-axis, away from the origin. Its angular momentum with respect to the origin

(A) is zero (B) remains constant

(C) goes on increasing (D) goes on decreasing

Q 5. A parallel combination of 0.1 MΩ resistor and a 10 μF capacitor is connected across a 1.5 V source of negligible resistance. The time required for the capacitor to get charged upto 0.75 V is approximately (in second)

(A) infinite (B) $\log_e 2$ (C) $\log_{10} 2$ (D) zero

Q 6. A non-conducting ring of radius 0.5 m carries a charge of 1.11×10^{-10} C distributed non-uniformly on its circumference producing an electric field E everywhere in space. The value of the integral $\int_{l=\infty}^{l=0} -\vec{E} \cdot \mathrm{d}\vec{l}$, ($l = 0$ being centre of the ring) in Volt is

(A) $+2$ (B) -1 (C) -2 (D) zero

Q 7. An electron of mass m_e, initially at rest, moves through a certain distance in a uniform electric field in time t_1. A proton of mass m_p, also initially at rest, takes time t_2 to move through an equal distance in this uniform electric field. Neglecting the effect of gravity, the ratio t_2/t_1 is nearly equal to

(A) 1 (B) $(m_p/m_e)^{1/2}$ (C) $(m_e/m_p)^{1/2}$ (D) 1836

Q 8. A steady current flows in a metallic conductor of non-uniform cross-section. The quantity/quantities constant along the length of the conductor is (are)

(A) current, electric field and drift speed

(B) drift speed only

(C) current and drift speed

(D) current only

Q 9. A whistle giving out 450 Hz approaches a stationary observer at a speed of 33 m/s. The frequency heard by the observer is [Speed of sound = 330 m/s.]
(A) 409 Hz (B) 429 Hz (C) 517 Hz (D) 500 Hz

Q 10. An eye specialist prescribes spectacles having combination of convex lens of focal length 40 cm in contact with a concave lens of focal length 25 cm. The power of thin lens combination in diopters is
(A) $+1.5$ (B) -1.5 (C) $+6.67$ (D) -6.67

Q 11. Masses of two isobars $_{29}Cu^{64}$ and $_{30}Zn^{64}$ are 63.9298 u and 63.9292 u respectively. It can be concluded from these data that

(A) both the isobars are stable.

(B) Zn^{64} is radioactive, decaying to Cu^{64} through β-decay.

(C) Cu^{64} is radioactive, decaying to Zn^{64} through γ-decay.

(D) Cu^{64} is radioactive, decaying to Zn^{64} through β-decay.

Q 12. The dominant mechanisms for motion of charge carriers in forward and reverse biased silicon p-n junctions are
(A) drift in forward bias, diffusion in reverse bias.
(B) diffusion in forward bias, drift in reverse bias.
(C) diffusion in both forward and reverse bias.
(D) drift in both forward and reverse bias.

Q 13. The K_α X-ray emission line of tungsten occurs at $\lambda = 0.021$ nm. The energy difference between K and L levels in this atom is about
(A) 0.51 MeV (B) 1.2 MeV (C) 59 keV (D) 13.6 eV

Q 14. The average translational energy and the *rms* speed of molecules in a sample of oxygen gas at 300 K are 6.21×10^{-21} J and 484 m/s, respectively. The corresponding values at 600 K are nearly (assuming ideal gas behaviour)

(A) 12.42×10^{-21} J, 968 m/s
(B) 8.78×10^{-21} J, 684 m/s
(C) 6.21×10^{-21} J, 968 m/s
(D) 12.42×10^{-21} J, 684 m/s

Q 15. The intensity of radiation emitted by the sun has its maximum value at a wavelength of 510 nm and that emitted by the north star has the maximum value at 350 nm. If these stars behaves like black bodies, then the ratio of the surface temperature of the sun and the north star is

(A) 1.46 (B) 0.69 (C) 1.21 (D) 0.83

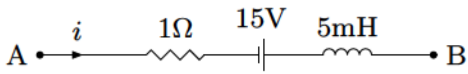
Fill in the Blank Type

There are 10 fill in the blank(s) type questions in this section. Each question is of two marks.

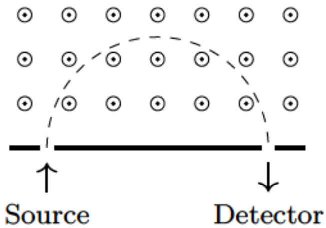
Q 16. A uniform disc of mass m and radius R is rolling up a rough inclined plane which makes an angle of 30° with the horizontal. If the coefficients of static and kinetic friction are each equal to μ and the only forces acting are gravitational and frictional, then the magnitude of the frictional force acting on the disc is ...... and its direction is ...... (write up or down) the inclined plane.

Q 17. The ratio of earth's orbital angular momentum (about the sun) to its mass is 4.4×10^{15} m^2/s. The area enclosed by earth's orbit is approximately ...... m^2.

Q 18. The network shown in the figure is part of a complete circuit. If at a certain instant the current (i) is 5 A and is decreasing at a rate of 10^3 A/s then $V_B - V_A = \ldots\ldots$ V.



Q 19. A uniform magnetic field with a slit system as shown in the figure is to be used as momentum filter for high-energy charged particles. With a field B Tesla, it is found that the filter transmits α-particles each of energy 5.3 MeV. The magnetic field is increased to 2.3B Tesla and deuterons are passed into the filter. The energy of each deuteron transmitted by the filter is ...... MeV.



Q 20. The recoil speed of a hydrogen atom after it emits a photon in going from $n = 5$ state to $n = 1$ state is ...... m/s.

Q 21. The trajectory of a projectile in a vertical plane is $y = ax - bx^2$, where a, b are constants, and x and y are respectively the horizontal and vertical distances of the projectile from the point of projection. The maximum height attained is ...... and the angle of projection from the horizontal is ......

Q 22. The dimensions of electrical conductivity is ......

Q 23. A gas thermometer is used as a standard thermometer for measurement of temperature. When the gas container of the thermometer is immersed in water at its triple point 273.16 K, the pressure in the gas thermometer reads 3.0×10^4 N/m^2. When the gas container of the same thermometer is immersed in another system, the gas pressure reads 3.5×10^4 N/m^2. The temperature of this system is therefore ...... °C.

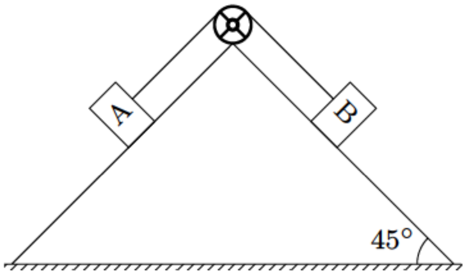
Q 24. A plane progressive wave of frequency 25 Hz, amplitude 2.5×10^{-5} m and initial phase zero, propagates along the negative x direction with a velocity of 300 m/s. At any instant, the phase difference between the oscillations at two points 6 m apart along the line of propagation is ...... and the corresponding amplitude difference is ...... m.

Q 25. A slit of width d is placed in front of a lens of focal length 0.5 m and is illuminated normally with light of wavelength 5.89×10^{-7} m. The first diffraction minima on either side of the central diffraction maximum are separated by 2×10^{-3} m. The width d of the slit is ...... m.

Descriptive

There are decriptive questions in this section.

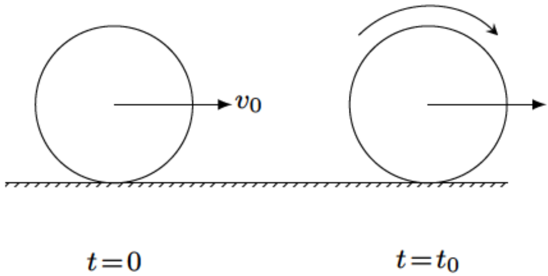
Q 26. Block A of mass m and block B of mass $2m$ are placed on a fixed triangular wedge by means of a massless, inextensible string and a frictionless pulley as shown in the figure. The wedge is inclined at 45° to the horizontal on both sides. The coefficient of friction between block A and the wedge is $2/3$ and that between block B and the wedge is $1/3$. If the blocks A and B are released from rest, find,



(a) the acceleration of A.
(b) tension in the string.
(c) the magnitude and direction of friction force acting on A.

Q 27. In an ore containing uranium, the ratio of ^{238}U to ^{206}Pb nuclei is 3. Calculate the age of the ore, assuming that all the lead present in the ore is the final stable product of ^{238}U. Take the half-life of ^{238}U to be 4.5×10^9 years.

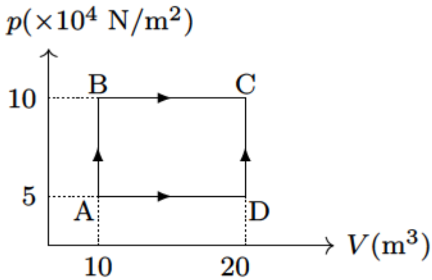
Q 28. A uniform disc of mass m and radius R is projected horizontally with velocity v_0 on a rough horizontal floor, so that it starts off with a purely sliding motion at $t = 0$. After t_0 seconds, it acquires a pure rolling motion as shown in the figure.



(a) Calculate the velocity of the centre of mass of the disc at t_0.

(b) Assuming the coefficient of friction to be μ, calculate t_0. Also calculate the work done by the frictional force as a function of time and the work done by it over a time t much longer than t_0.

Q 29. A sample of 2 kg monatomic helium (assume ideal) is taken through the process ABC and another sample of 2 kg of the same gas is taken through the process ADC (see figure). Given molecular mass of helium = 4.



(a) What is the temperature of helium in each of the states A, B, C and D?

(b) Is there any way of telling afterwards which sample of helium went through the process ABC and which went through the process ADC? Write Yes or No.

(c) How much is the heat involved in the process ABC and ADC?

Q 30. The first overtone of an open organ pipe beats with the first overtone of a closed organ pipe with a beat frequency of 2.2 Hz. The fundamental frequency of the closed organ pipe is 110 Hz. Find the lengths of the pipes. [Speed of sound in air is 330 m/s.]

Q 31. A large open top container of negligible mass and uniform cross-sectional area A has a small hole of cross-sectional area $A/100$ in its side wall near the bottom. The container is kept on a smooth horizontal floor and contains a liquid of density ρ and mass m_0. Assuming that the liquid starts flowing out horizontally through the hole at $t = 0$. Calculate,

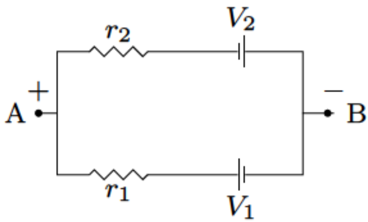
(a) the acceleration of the container.
(b) velocity of efflux when 75% of the liquid has drained out.

Q 32. A thin rod of negligible mass and area of cross-section 4×10^{-6} m^2, suspended vertically from one end, has a length of 0.5 m at 100 °C. The rod is cooled to 0 °C, but prevented from contracting by attaching a mass at the lower end. Find (a) the mass, and (b) the energy stored in the rod. [Given, for the rod, Young's modulus $= 10^{11}$ N/m^2, coefficient of linear expansion $= 10^{-5}$ /K and $g = 10$ m/s^2.]

Q 33. An infinitesimally small bar magnet of dipole moment $\vec{M}$ is pointing and moving with the speed v in the positive x direction. A small closed circular conducting loop of radius a and negligible self-inductance lies in the y-z plane with its centre at $x = 0$, and its axis coinciding with the x-axis. Find the force opposing the motion of the magnet, if the resistance of the loop is R. Assume that the distance x of the magnet from the centre of the loop is much greater than a.

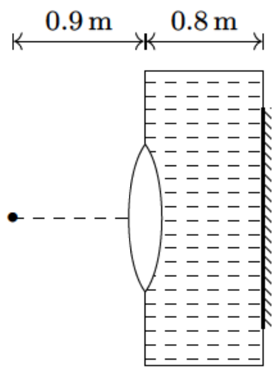
Q 34. A leaky parallel plate capacitor is filled completely with a material having electrical conductivity $\sigma = 7.4 \times 10^{-12}\,\Omega^{-1}\mathrm{m}^{-1}$ and dielectric constant $K = 5$. If the charge on the capacitor at instant $t = 0$ is $q = 8.85\,\mu\mathrm{C}$, then calculate the leakage current at the instant $t = 12$ s.

Q 35. Find the *emf* (V) and the internal resistance (r) of a single battery which is equivalent to a parallel combination of two batteries of *emfs* V_1 and V_2 and internal resistances r_1 and r_2 respectively, with polarities as shown in the figure.



Q 36. A double-pane window used for insulating a room thermally from outside consists of two glass sheets each of area 1 m^2 and thickness 0.01 m separated by a 0.05 m thick stagnant air space. In the steady state, the room glass interface and the glass-outdoor interface are at constant temperature of 27 °C and 0 °C respectively. Calculate the rate of heat flow through the window pane. Also find the temperatures of the other interfaces. Given thermal conductivities of glass and air as 0.8 and 0.08 W m^{-1} K^{-1}, respectively.

Q 37. A thin equi-convex lens of glass of refractive index $\mu = 3/2$ and of focal length 0.3 m in air is sealed into an opening at one end of a tank filled with water ($\mu = 4/3$). On the opposite side of the lens, a mirror is placed inside the tank on the tank wall perpendicular to the lens axis, as shown in the figure. The separation between the lens and the mirror is 0.8 m. A small object is placed outside the tank in front of lens at a distance of 0.9 m from the lens along its axis. Find the position (relative to the lens) of the image of the object formed by the system.



Q 38. In Young's double slit experiment, the source is red light of wavelength 7×10^{-7} m. When a thin glass plate of refractive index 1.5 at this wavelength is put in the path of one of the interfering beams, the central bright fringe shifts by 10^{-3} m to the position previously occupied by the 5^{th} bright fringe. Find the thickness of the plate. When the source is now changed to green light of wavelength 5×10^{-7} m, the central fringe shifts to a position initially occupied by the 6^{th} bright fringe due to red light. Find the refractive index of glass for green light. Also estimate the change in fringe width due to the change in wavelength.

Answers

1. C
2. C
3. A
4. B
5. D
6. A
7. B
8. D
9. D
10. B
11. D
12. B
13. C
14. D
15. B
16. $mg/6$, up
17. 6.94×10^{22}
18. 15
19. 14.0185
20. 4.17
21. $\frac{a^2}{4b}$, $\tan^{-1} a$
22. $[M^{-1}L^{-3}T^{3}A^{2}]$
23. 45.53 °C
24. π, zero
25. 2.945×10^{-4}
26. (a) 0 (b) $\frac{2\sqrt{2}}{3}mg$ (c) $\frac{mg}{3\sqrt{2}}$, downwards
27. 1.86×10^{9} years
28. (a) $\frac{2}{3}v_0$ (b) $\frac{v_0}{3\mu g}$, $\frac{\mu mgt}{2}(3\mu gt - 2v_0)$, $-\frac{mv_0^2}{6}$
29. (a) $T_A = 120.28$ K, $T_B = 240.56$ K, $T_C = 481.11$ K, $T_D = 240.56$ K (b) No (c) $Q_{\mathrm{ABC}} = 3.25 \times 10^{6}$ J, $Q_{\mathrm{ADC}} = 2.75 \times 10^{6}$ J
30. $l_o = 1 \pm 0.0067$ m, $l_c = 0.75$ m
31. (a) $\frac{g}{50}$ (b) $\sqrt{\frac{gm_0}{2A\rho}}$
32. (a) 40 kg (b) 0.1 J
33. $F = \frac{21}{4}\frac{\mu_0^2 M^2 a^4 v}{Rx^8}$, repulsion
34. 0.198 μA
35. $V = \frac{V_1 r_2 - V_2 r_1}{r_1 + r_2}$, $r = \frac{r_1 r_2}{r_1 + r_2}$

36. 41.5 W, 26.48 °C, 0.52 °C

37. 0.9 m right of the lens.

38. 7×10^{-6} m, 1.6, -0.57×10^{-4} m

IIT JEE 1996

IIT JEE 1996 has one physics paper of three hour duration.

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper

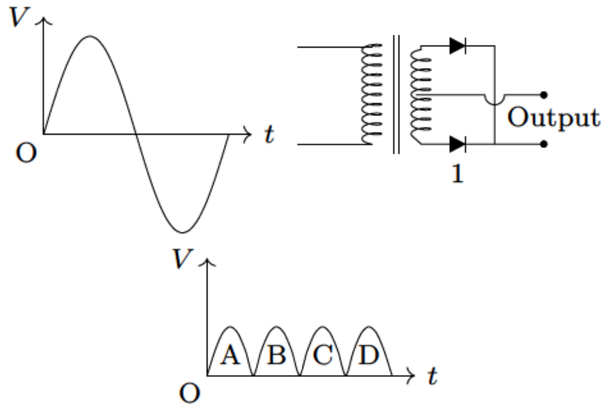
There are four types of questions (i) objective questions with single option correct (ii) objective questions with one or more option(s) correct (iii) fill in the blanks type and (iv) descriptive type. Total marks of the paper is 100 and there is no negative marking.

Note: The paper has 15 questions. One question has 5 parts of type (i), one question has 5 parts of type (ii), and one more question has 5 parts of type (iii). Other 12 questions are of descriptive types, some of them have multiple parts. These parts constitute separate questions.

One Option Correct

There are 5 questions in this section. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Each question is of two marks.

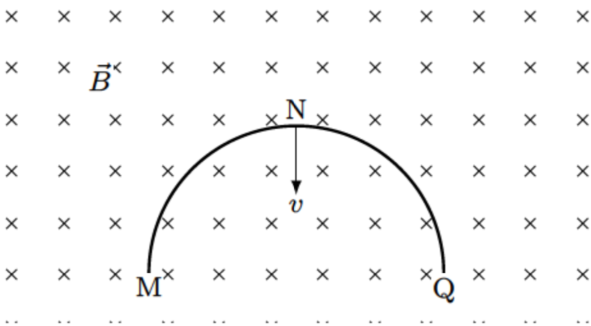
Q 1. A full wave rectifier circuit along with the output is shown in the figure. The contribution(s) from the diode 1 is (are)



(A) C (B) A, C (C) B, D (D) A, B, C, D

Q 2. If the distance between the earth and the sun were half of its present value, the number of days in a year would have been
(A) 64.5 (B) 129 (C) 182.5 (D) 730

Q 3. A thin semicircular conducting ring of radius R is falling with its plane vertical in a horizontal magnetic induction $\vec{B}$. At the position MNQ the speed of the ring is v and the potential difference developed across the ring is



(A) zero.
(B) $Bv\pi R^2/2$ and M is at higher potential.
(C) πBRv and Q is at higher potential.
(D) $2BRv$ and Q is at higher potential.

Q 4. The extension in a string, obeying Hooke's law, is x. The speed of transverse wave in the stretched string is v. If the extension in the string is increased to $1.5x$, the speed of transverse wave will be
(A) $1.22v$ (B) $0.61v$ (C) $1.50v$ (D) $0.75v$

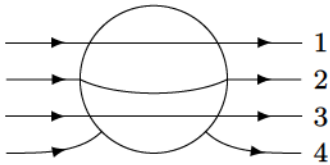
Q 5. An open pipe is suddenly closed at one end with the result that the frequency of the third harmonic of the closed pipe is found to be higher by 100 Hz than the fundamental frequency of the open pipe. The fundamental frequency (in Hz) of the open pipe is
(A) 200 (B) 300 (C) 240 (D) 480

One or More Option(s) Correct

There are 5 questions in this section. Each question has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 6. The temperature of an ideal gas is increased from 120 K to 480 K. If at 120 K the *rms* velocity of the gas molecules is v, at 480 K it becomes
(A) $4v$ (B) $2v$ (C) $v/2$ (D) $v/4$

Q 7. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the path(s) shown in the figure as



(A) 1 (B) 2 (C) 3 (D) 4

Q 8. The magnitude of electric field $\vec{E}$ in the annular region of a charged cylindrical capacitor,

(A) is same throughout.

(B) is higher near the outer cylinder than near the inner cylinder.

(C) varies as $1/r$ where r is the distance from the axis.

(D) varies as $1/r^2$ where r is the distance from the axis.

Q 9. Which of the following form(s) a virtual and erect image for all positions of the object?

(A) Convex lens (B) Concave lens

(C) Convex mirror (D) Concave mirror

Q 10. Holes are charge carriers in

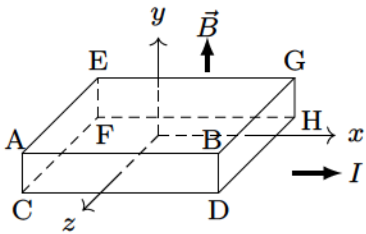
(A) intrinsic semiconductors (B) ionic solids

(C) p-type semiconductors (D) metals

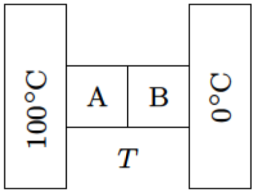
Fill in the Blank Type

There are 5 fill in the blank(s) type questions in this section. Each question is of two marks.

Q 11. A metallic block carrying current I is subjected to a uniform magnetic induction $\vec{B}$ as shown in the figure. The moving charges experience a force $\vec{F}$ given by ...... which results in the lowering of the potential of the face .... Assume the speed of the charges to be v.



Q 12. Two metal cubes A and B of the same size are arranged as shown in the figure. The extreme ends of the combination are maintained at the indicated temperatures. The arrangement is thermally insulated. The coefficients of thermal conductivity of A and B are 300 W/m °C and 200 W/m °C, respectively. After steady state is reached the temperature T of the interface will be ......



Q 13. A potential difference of 20 kV is applied across an X-ray tube. The minimum wavelength of X-rays generated is ...... Å.

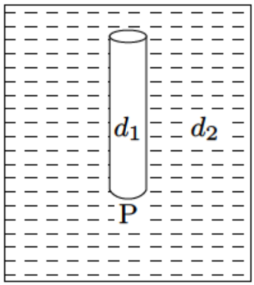
Q 14. The wavelength of K_α X-rays produced by an X-ray tube is 0.76 Å. The atomic number of the anode material of the tube is ……

Q 15. Consider the reaction: ${}_1^2\mathrm{H} + {}_1^2\mathrm{H} = {}_2^4\mathrm{He} + Q$. Mass of the deuterium atom = 2.0141 u and mass of helium atom = 4.0024 u. This is a nuclear ...... reaction in which the energy Q released is ...... MeV.

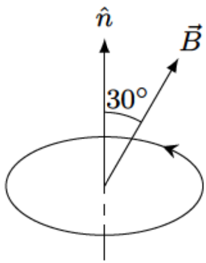
Descriptive

This section contains decriptive questions. Solve all of them.

Q 16. A thin rod of length L and uniform cross-section is pivoted at its lowest point P inside a stationary homogeneous and non-viscous liquid. The rod is free to rotate in a vertical plane about a horizontal axis passing through P. The density d_1 of the material of the rod is smaller than the density d_2 of the liquid. The rod is displaced by small angle θ from its equilibrium position and then released. Show that the motion of the rod is simple harmonic and determine its angular frequency in terms of the given parameters.



Q 17. An electron in the ground state of hydrogen atom is revolving in anticlockwise direction in a circular orbit of radius R (see figure).

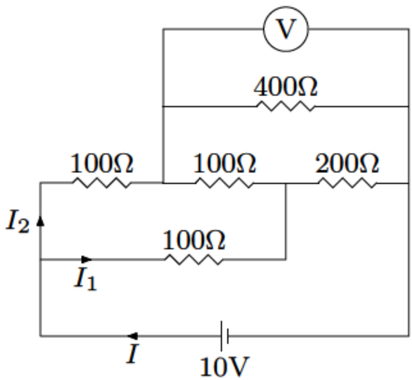


(a) Obtain an expression for the orbital magnetic moment of the electron.

(b) The atom is placed in a uniform magnetic induction $\vec{B}$ such that the normal to the plane of electron's orbit makes an angle of 30° with the magnetic induction. Find the torque experienced by the orbiting electron.

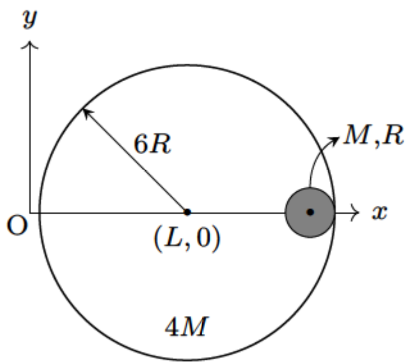
Q 18. A solenoid has an inductance of 10 H and a resistance of 2 Ω. It is connected to a 10 V battery. How long will it take for the magnetic energy to reach 1/4 th of its maximum value?

Q 19. An electrical circuit is shown in the figure. Calculate the potential difference across the resistor of 400 Ω as will be measured by the voltmeter V of resistance 400 Ω either by applying Kirchhoff's rules or otherwise.

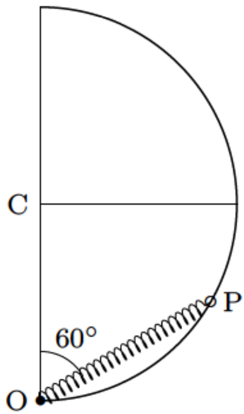


Q 20. Distance between the centres of two stars is $10a$. The masses of the stars are M and $16M$ and their radii a and $2a$ respectively. A body of mass m is fired straight from the surface of the larger star towards the surface of the smaller star. What should be its minimum initial speed to reach the surface of the smaller star? Obtain the expression in terms of G, M and a.

Q 21. A small sphere of radius R is held against the inner surface of a larger sphere of radius $6R$. The masses of large and small spheres are $4M$ and M respectively. This arrangement is placed on a horizontal table. There is no friction between any surface of contact. The small sphere is now released. Find the coordinates of the centre of the larger sphere when the smaller sphere reaches the other extreme position.



Q 22. A smooth semicircular wire track of radius R is fixed in a vertical plane (see figure). One end of massless spring of natural length $3R/4$ is attached to the lowest point O of the wire track. A small ring of mass m which can slide on the track is attached to the other end of the spring. The ring is held stationary at point P such that the spring makes an angle $60°$ with the vertical. The spring constant is $k = mg/R$. Consider the instant when the ring is released (a) draw the free body diagram of the ring, and (b) determine the tangential acceleration of the ring and the normal reaction.



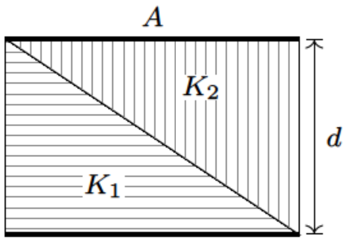
Q 23. Two guns situated on the top of a hill of height 10 m fire one shot each with the same speed $5\sqrt{3}$ m/s at some interval of time. One gun fires horizontally and other fires upwards at an angle $60°$ with the horizontal. The shots collide in air at point P. Find, [Take $g = 10\ \mathrm{m/s^2}$.]

(a) the time interval between the firings.

(b) the coordinates of the point P. Take origin of the coordinate system at the foot of the hill right below the muzzle and trajectory in x-y plane.

Q 24. Two isolated metallic solid spheres of radii R and $2R$ are charged such that both of these have same charge density σ. The spheres are located far away from each other and connected by a thin conducting wire. Find the new charge density on the bigger sphere.

Q 25. The capacitance of a parallel plate capacitor with plate area A and separation d, is C. The space between the plates is filled with two wedges of dielectric constant K_1 and K_2 respectively (see figure). Find the capacitance of the resulting capacitor.

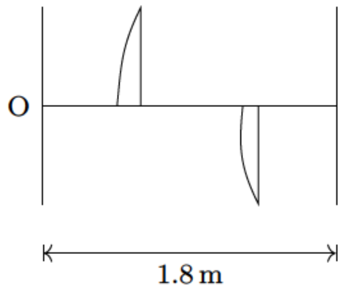


Q 26. An electron in a hydrogen like atom is in an excited state. It has a total energy of -3.4 eV. Calculate,

(a) the kinetic energy.
(b) the de-Broglie wavelength of the electron.

Q 27. A whistle emitting a sound of frequency 440 Hz is tied to a string of 1.5 m length and rotated with an angular velocity of 20 rad/s in the horizontal plane. Calculate the range of frequencies heard by an observer stationed at a large distance from the whistle. [Speed of sound = 330 m/s.]

Q 28. A thin plano-convex lens of focal length f is split into two halves. One of the halves is shifted along the optical axis. The separation between object and image planes is 1.8 m. The magnification of the image formed by one of the half lens is 2. Find the focal length of the lens and separation between the halves. Draw the ray diagram for image formation.

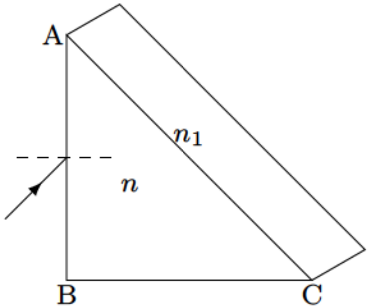


Q 29. A double slit apparatus is immersed in a liquid of refractive index 1.33. It has slit separation of 1 mm and distance between the plane of slits and screen is 1.33 m. The slits are illuminated by a parallel beam of light whose wavelength in air is 6300 Å.

(a) Calculate the fringe width.

(b) One of the slits of the apparatus is covered by a thin glass sheet of refractive index 1.53. Find the smallest thickness of the sheet to bring the adjacent minimum at the axis.

Q 30. A right angled prism (45°-90°-45°) of refractive index n has a plane of refractive index $n_1 (n_1 < n)$ cemented to its diagonal face. The assembly is in air. The ray is incident on AB.



(a) Calculate the angle of incidence at AB for which the ray strikes the diagonal face at the critical angle.

(b) Assuming $n = 1.352$, calculate the angle of incidence at AB for which the refracted ray passes through the diagonal face undeviated.

Q 31. Angular width of central maximum in the Fraunhoffer diffraction pattern of the slit is measured. The slit is illuminated by light of wavelength 6000 Å. When the slit is illuminated by light of another wavelength, the angular width decreased by 30%. Calculate the wavelength of this light. The same decrease in the angular width of central maximum is obtained when the original apparatus is immersed in a liquid. Find refractive index of the liquid.

Q 32. The temperature of 100 g of water is to be raised from 24 °C to 90 °C by adding steam to it. Calculate the mass of the steam required for this purpose.

Q 33. At 27 °C two moles of an ideal monatomic gas occupy a volume V. The gas expands adiabatically to a volume $2V$. Calculate,

(a) the final temperature of the gas.
(b) change in its internal energy.
(c) the work done by the gas during this process.

Q 34. At a given instant there are 25% undecayed radioactive nuclei in a sample. After 10 s the number of undecayed nuclei reduces to 12.5%. Calculate,

(a) mean life of nuclei.

(b) the time in which the number of undecayed nuclei will further reduce to 6.25% of the reduced number.

Answers

1. B, C
2. B
3. D
4. A
5. A
6. B
7. D
8. C
9. B, C
10. A, C
11. $evB\hat{k}$, ABDC
12. 60 °C
13. 0.62
14. 41
15. fusion, 24
16. $\sqrt{\frac{3}{2}\left(\frac{d_2-d_1}{d_1}\right)\frac{g}{L}}$
17. (a) $\frac{eh}{4\pi m}$ (b) $\frac{ehB}{8\pi m}$
18. 3.465 s
19. $\frac{20}{3}$ V
20. $\frac{3}{2}\sqrt{\frac{5GM}{a}}$
21. $(L+2R, 0)$
22. (b) $\frac{5\sqrt{3}}{8}g$, $\frac{3mg}{8}$
23. (a) 1 s (b) $(5\sqrt{3}\ \text{m}, 5\ \text{m})$
24. $\frac{5}{6}\sigma$
25. $\frac{\epsilon_0 A}{d}\frac{K_1K_2}{K_2-K_1}\ln\frac{K_2}{K_1}$
26. (a) 3.4 eV (b) 6.66 Å
27. 403.3 Hz to 484 Hz
28. 0.4 m, 0.6 m
29. (a) 0.63 mm
    (b) 1.579 µm
30. (a) $\sin^{-1}\left[\frac{1}{\sqrt{2}}\left(\sqrt{n^2-\right.\right.$
    (b) 73°
31. 4200 Å, 1.43
32. 12 g
33. (a) 189 K (b) −2768 J
    (c) 2768 J
34. (a) 14.43 s (b) 40 s

IIT JEE 1995

IIT JEE 1995 has a screening paper and a main paper.

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Screening Paper

The physics part of the screening paper has two sections (i) objective questions with single option correct (ii) objective questions with one or more option(s) correct.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

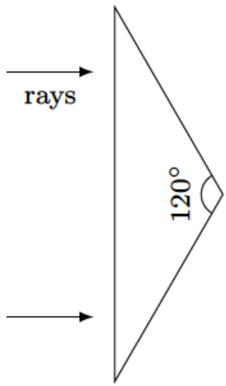
Q 1. Two metallic spheres S_1 and S_2 are made of the same material and have got identical surface finish. The mass of S_1 is thrice that of S_2. Both the spheres are heated to the same high temperature and placed in the same room having lower temperature but are thermally insulated from each other. The ratio of the initial rate of cooling of S_1 to that of S_2 is

(A) $\frac{1}{3}$ (B) $\frac{1}{\sqrt{3}}$ (C) $\sqrt{3}$ (D) $\left(\frac{1}{3}\right)^{1/3}$

Q 2. Three rods of identical cross-sectional area and made from the same metal form the sides of an isosceles triangle ABC, right angled at B. The points A and B are maintained at temperatures T and $\sqrt{2}T$, respectively. In the steady state, the temperature of the point C is T_c. Assuming that only heat conduction takes place, T_c/T is

(A) $\frac{1}{2(\sqrt{2}-1)}$ (B) $\frac{3}{\sqrt{2}+1}$ (C) $\frac{1}{\sqrt{3}(\sqrt{2}-1)}$ (D) $\frac{1}{\sqrt{2}+1}$

Q 3. An isosceles prism of angle 120° has a refractive index 1.44. Two parallel rays of monochromatic light enter the prism parallel to each other in air as shown. The rays emerging from the opposite face



(A) are parallel to each other.
(B) are diverging.
(C) make an angle $2[\sin^{-1}(0.72) - 30°]$ with each other.
(D) make an angle $2\sin^{-1}(0.72)$ with each other.

Q 4. The focal lengths of the objective and the eye-piece of a compound microscope are 2.0 cm and 3.0 cm respectively. The distance between the objective and the eyepiece is 15.0 cm. The final image formed by the eyepiece is at infinity. The two lenses are thin. The distance (in cm) of the object and the image produced by the objective, measured from the objective lens, are respectively,

(A) 2.4 and 12.0 (B) 2.4 and 15.0
(C) 2.0 and 12.0 (D) 2.0 and 3.0

Q 5. A diminished image of an object is to be obtained on a screen 1.0 m from it. This can be achieved by placing

(A) a concave mirror of suitable focal length.

(B) a convex mirror of suitable focal length.

(C) a convex lens of focal length less than 0.25 m.

(D) a concave lens of suitable focal length.

Q 6. In the formula $X = 3YZ^2$, X and Z have dimensions of capacitance and magnetic induction, respectively. The dimensions of Y in MKSQ system is
(A) $[\mathrm{M^{-3}L^{-1}T^{3}Q^{4}}]$ (B) $[\mathrm{M^{-3}L^{-2}T^{4}Q^{4}}]$
(C) $[\mathrm{M^{-2}L^{-2}T^{4}Q^{4}}]$ (D) $[\mathrm{M^{-3}L^{-2}T^{4}Q}]$

Q 7. An object of specific gravity ρ is hung from a thin steel wire. The fundamental frequency for transverse standing waves in the wire is 300 Hz. The object is immersed in water, so that one half of its volume is submerged. The new fundamental frequency (in Hz) is

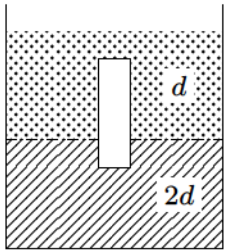
(A) $300\left(\frac{2\rho-1}{2\rho}\right)^{\frac{1}{2}}$ (B) $300\left(\frac{2\rho}{2\rho-1}\right)^{\frac{1}{2}}$

(C) $300\left(\frac{2\rho}{2\rho-1}\right)$ (D) $300\left(\frac{2\rho-1}{2\rho}\right)$

Q 8. Two point masses of 0.3 kg and 0.7 kg are fixed at the ends of a rod of length 1.4 m and of negligible mass. The rod is set rotating about an axis perpendicular to its length with a uniform angular speed. The point on the rod through which the axis should pass in order that the work required for rotation of the rod is minimum, is located at a distance of

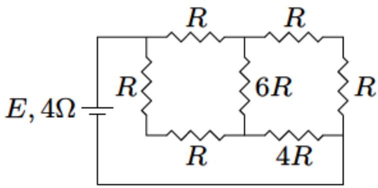
(A) 0.42 m from mass of 0.3 kg
(B) 0.70 m from mass of 0.7 kg
(C) 0.98 m from mass of 0.3 kg
(D) 0.98 m from mass of 0.7 kg

Q 9. A homogeneous solid cylinder of length L and cross-sectional area $A/5$ is immersed such that it floats with its axis vertical at the liquid-liquid interface with length $L/4$ in the denser liquid as shown in the figure. The lower density liquid is open to atmosphere having pressure P_0. Then, density D of solid is given by



(A) $\frac{5}{4}d$ (B) $\frac{4}{5}d$ (C) $4d$ (D) $\frac{d}{5}$

Q 10. A battery of internal resistance 4 Ω is connected to the network resistances as shown in the figure. In order that the maximum power can be delivered to the network, the value of R (in Ω) should be



(A) 4/9 (B) 2 (C) 8/3 (D) 18

Q 11. Two point charges $+q$ and $-q$ are held fixed at $(-d, 0)$ and $(d, 0)$ respectively of a x-y coordinate system. Then,

(A) the electric field E at all points on the x-axis has the same direction.

(B) work has to be done in bringing a test charge from ∞ to the origin.

(C) electric field at all point on y-axis is along x-axis.

(D) the dipole moment is $2qd$ along the x-axis.

Q 12. A parallel plate capacitor of capacitance C is connected to a battery and is charged to a potential difference V. Another capacitor of capacitance $2C$ is similarly charged to a potential difference $2V$. The charging battery is now disconnected and the capacitors are connected in parallel to each other in such a way that the positive terminal of one is connected to the negative terminal of the other. The final energy of the configuration is

(A) zero (B) $\frac{3}{2}CV^2$ (C) $\frac{25}{6}CV^2$ (D) $\frac{9}{2}CV^2$

Q 13. A battery is connected between two points A and B on the circumference of a uniform conducting ring of radius r and resistance R. One of the arcs AB of the ring subtends an angle θ at the centre. The value of the magnetic induction at the centre due to the current in the ring is

(A) proportional to $(180° - \theta)$

(B) inversely proportional to r

(C) zero, only if $\theta = 180°$

(D) zero for all values of θ

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four options is(are) correct.

Q 14. The pairs of physical quantities that have the same dimensions is (are)

(A) Reynolds number and coefficient of friction.

(B) Curie and frequency of a light wave.

(C) Latent heat and gravitational potential.

(D) Planck's constant and torque.

Q 15. A wave disturbance in a medium is described by,

$$y(x,t) = 0.02\cos(50\pi t + \pi/2)\cos(10\pi x),$$

where x and y are in metre and t is in second.

(A) A node occurs at $x = 0.15$ m
(B) An antinode occurs at $x = 0.3$ m
(C) The speed of wave is 5 m/s
(D) The wavelength of wave is 0.2 m

Q 16. A sound wave of frequency f travels horizontally to the right. It is reflected from a large vertical plane surface moving to left with a speed v. The speed of sound in medium is c.

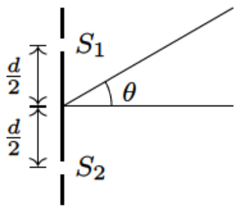
(A) The number of waves striking the surface per second is $\frac{f(c+v)}{c}$.

(B) The wavelength of reflected wave is $\frac{c(c-v)}{f(c+v)}$.

(C) The frequency of the reflected wave is $\frac{f(c+v)}{c-v}$.

(D) The number of beats heard by a stationary listener to the left of the reflecting surface is $\frac{vf}{c-v}$.

Q 17. In an interference arrangement similar to Young's double slit experiment, the slits S_1 and S_2 are illuminated with coherent microwave sources, each of frequency 10^6 Hz. The sources are synchronized to have zero phase difference. The slits are separated by a distance $d = 150.0$ m. The intensity $I(\theta)$ is measured as a function of θ, where θ is defined as shown. If I_0 is the maximum intensity, then $I(\theta)$ for $0 \leq \theta \leq 90°$ is given by



(A) $I(\theta) = I_0/2$ for $\theta = 30°$
(B) $I(\theta) = I_0/4$ for $\theta = 90°$
(C) $I(\theta) = I_0$ for $\theta = 0°$
(D) $I(\theta)$ is constant for all θ

Q 18. From the following statements concerning ideal gas at any given temperature T, select the correct one(s),

(A) The coefficient of volume expansion at constant pressure is the same for all ideal gases.

(B) The average translational kinetic energy per molecule of oxygen gas is $3\,kT$, k being Boltzmann constant.

(C) The mean-free path of molecules increases with decrease in the pressure.

(D) In a gaseous mixture, the average translational kinetic energy of the molecules of each component is different.

Answers

1. D
2. B
3. C
4. A
5. C
6. B
7. A
8. C
9. A
10. B
11. C
12. B
13. D
14. A, B, C
15. A, B, C, D
16. A, B, C
17. A, C
18. A, C

Main Paper

The main paper in physics is of two hour duration. There are six descriptive questions of of total marks 60.

Descriptive

There are six questions of 10 marks each. Solve all the questions.

Q 1. In a photoelectric effect set-up, a point source of light of power 3.2×10^{-3} W emits mono-energetic photons of energy 5.0 eV. The source is located at a distance of 0.8 m from the centre of a stationary metallic sphere of work function 3.0 eV and of radius 8.0×10^{-3} m. The efficiency of photoelectrons emission is one for every 10^6 incident photons. Assume that the sphere is isolated and initially neutral and that photoelectrons are instantly swept away after emission.

(a) Calculate the number of photoelectrons emitted per second.

(b) Find the ratio of the wavelength of incident light to the de-Broglie wavelength of the fastest photoelectrons emitted.

(c) It is observed that the photoelectrons emission stops at a certain time t after the light source is switched on. Why?

(d) Evaluate the time t.

Q 2. A gaseous mixture enclosed in a vessel of volume V consists of one mole of gas A with $\gamma = C_p/C_V = 5/3$ and another gas B with $\gamma = 7/5$ at a certain temperature T. The molecular weights of the gases A and B are 4 and 32, respectively. The gases A and B do not react with each other and are assumed to be ideal. The gaseous mixture follows the equation $pV^{19/13} =$ constant, in adiabatic processes.

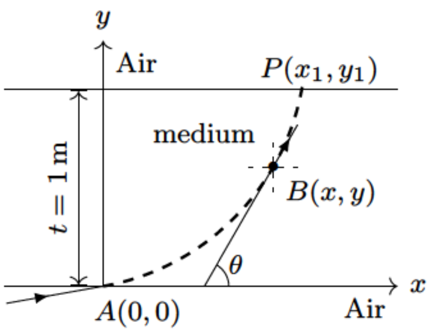
(a) Find the number of moles of the gas B in the gaseous mixture.

(b) Compute the speed of sound in the gaseous mixture at 300 K.

(c) If T is raised by 1 K from 300 K, find the percentage change in the speed of sound in the gaseous mixture.

(d) The mixture is compressed adiabatically to $1/5$ th of its initial volume V. Find the change in its adiabatic compressibility in terms of the given quantities.

Q 3. A ray of light travelling in air is incident at grazing angle (incident angle = 90°) on a long rectangular slab of a transparent medium of thickness $t = 1.0$ m. The point of incidence is the origin $A(0,0)$. The medium has a variable index of refraction $n(y)$ given by $n(y) = \left[ky^{3/2} + 1\right]^{1/2}$, where $k = 1.0\,\mathrm{m}^{-3/2}$. The refractive index of air is 1.0.



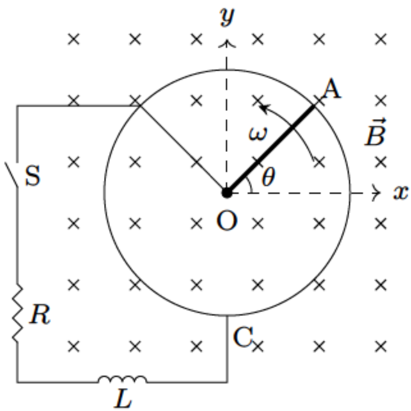
(a) Obtain a relation between the slope of the trajectory of the ray at a point $B(x, y)$ in the medium and the incident angle at that point.

(b) Obtain an equation for the trajectory $y(x)$ of the ray in the medium.

(c) Determine the coordinates (x_1, y_1) of the point P, where the ray intersects the upper surface of the slab-air boundary.

(d) Indicate the path of the ray subsequently.

Q 4. A metal rod OA of mass m and length r is kept rotating with a constant angular speed ω in a vertical plane about horizontal axis at the end O. The free end A is arranged to slide without friction along a fixed conducting circular ring in the same plane as that of rotation. A uniform and constant magnetic induction $\vec{B}$ is applied perpendicular and into the plane of rotation as shown in the figure. An inductor L and an external resistance R are connected through a switch S between the point O and a point C on the ring to form an electric circuit. Neglect the resistance of the ring and the rod. Initially, the switch is open.



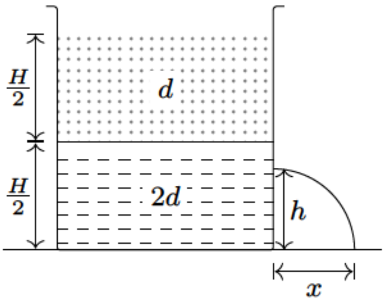
(a) What is the induced *emf* across the terminals of the switch?

(b) The switch S is closed at time $t = 0$,

(i) Obtain an expression for the current as a function of time.

(ii) In the steady state, obtain the time dependence of the torque required to maintain the constant angular speed. Given that the rod OA was along the positive x-axis at $t = 0$.

Q 5. A container of large uniform cross-sectional area A resting on a horizontal surface, holds two immiscible, non-viscous and incompressible liquids of densities d and $2d$, each of height $H/2$ as shown in the figure. The lower density liquid is open to the atmosphere having pressure p_0.



(a) A homogeneous solid cylinder of length $L\,(L < H/2)$, cross-sectional area $A/5$ is immersed such that it floats with its axis vertical at the liquid-liquid interface with length $L/4$ in the denser liquid. Determine,

(i) the density of the solid.

(ii) the total pressure at the bottom of the container.

(b) The cylinder is removed and the original arrangement is restored. A tiny hole of area $s\,(s \ll A)$ is punched on the vertical side of the container at a height $h\,(h < H/2)$. Determine,

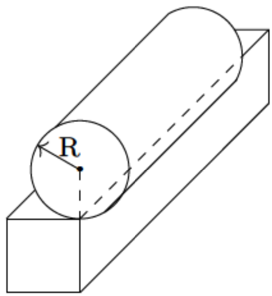
(i) the initial speed of efflux of the liquid at the hole.

(ii) the horizontal distance x travelled by the liquid initially.

(iii) the height h_m at which the hole should be punched so that the liquid travels the maximum distance x_m initially. Also calculate x_m.

[Neglect the air resistance in these calculations.]

Q 6. A rectangular rigid fixed block has a long horizontal edge. A solid homogeneous cylinder of radius R is placed horizontally at rest with its length parallel to the edge such that the axis of the cylinder and the edge of the block are in the same vertical plane as shown in the figure. There is sufficient friction present at the edge, so that a very small displacement causes the cylinder to roll off the edge without slipping. Determine,



(a) the angle θ_c through which the cylinder rotates before it leaves contact with the edge.
(b) the speed of the centre of mass of the cylinder before leaving contact with the edge.
(c) the ratio of the translational to rotational kinetic energies of the cylinder when its centre of mass is in horizontal line with the edge.

Answers

1. (a) 10^5 /s (b) 286 (c) Emission of photoelectrons is stopped when its potential is equal to the stopping potential required for the fastest moving electrons. (d) 111 s

2. (a) 2 mol (b) 401 m/s (c) 0.167% (d) $-8.27 \times 10^{-5} V$

3. (a) slope = $\cot i$ (b) $4y^{1/4} = x$ (c) $(4\,\text{m}, 1\,\text{m})$ (d) the ray will emerge parallel to the incident ray

4. (a) $\frac{B\omega r^2}{2}$ (b) (i) $\frac{B\omega r^2}{2R}\left[1 -\right.$ (ii) $\frac{B^2\omega r^4}{4R} + \frac{mgr}{2}\cos\omega t$

5. (a) (i) $\frac{5d}{4}$ (ii) $p = p_0 + \frac{dg(6H+L)}{4}$ (b) (i) $\sqrt{(3H-4h)\frac{g}{2}}$ (ii) $\sqrt{h(3H-4h)}$ (iii) $\frac{3H}{8}, \frac{3H}{4}$

6. (a) $\cos^{-1}(4/7)$ (b) $\sqrt{4gR/7}$ (c) 6

IIT JEE 1994

IIT JEE 1994 has one physics paper of three hour duration.

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Paper

The paper is divided into two parts, (A) and (B). The questions in part (A) has (i) objective questions with single option correct (ii) objective questions with one or more option(s) correct and (iii) fill in the blanks type. The part (B) has descriptive questions. Total marks of the paper is 100 and there is no negative marking.

One Option Correct

This is part (A) of the paper. There are six questions in this section. Each question has four options (A), (B), (C) and (D). Only one of these four options is correct. Each question is of one mark.

Q 1. Consider α-particles, β-particles and γ-rays each having an energy of 0.5 MeV. In increasing order of penetrating powers, the radiations are
(A) α, β, γ (B) α, γ, β (C) β, γ, α (D) γ, β, α

Q 2. A narrow slit of width 1 mm is illuminated by monochromatic light of wavelength 600 nm. The distance between the first minima on the either side of a screen at a distance of 2 m is

(A) 1.2 cm (B) 1.2 mm (C) 2.4 cm (D) 2.4 mm

Q 3. Spherical aberration in a thin lens can be reduced by

(A) using a monochromatic light.
(B) using a doublet combination.
(C) using a circular annular mask over the lens.
(D) increasing the size of the lens.

Q 4. A particle of mass m is moving in a circular path of constant radius r such that its centripetal acceleration a_c is varying with time t as $a_c = k^2rt^2$, where k is a constant. The power delivered to the particle by the force acting on it is

(A) $2\pi mk^2r^2$ (B) mk^2r^2t (C) $\frac{1}{3}mk^4r^2t^5$ (D) zero

Q 5. A block of mass 0.1 kg is held against a wall by applying a horizontal force of 5 N on the block. If the coefficient of friction between the block and the wall is 0.5, the magnitude of the frictional force acting on the block is
(A) 2.5 N (B) 0.98 N (C) 4.9 N (D) 0.49 N

Q 6. Fast neutrons can easily be slowed down by
(A) the use of lead shielding.
(B) passing them through heavy water.
(C) elastic collisions with heavy nuclei.
(D) applying a strong electric field.

One or More Option(s) Correct

This is also part (A) of the paper. There are six questions in this section. Each question has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 7. Two bodies A and B have thermal emissivities of 0.01 and 0.81, respectively. The outer surface area of the two bodies are the same. The two bodies emit total radiant power at the same rate. The wavelength λ_B corresponding to maximum spectral radiance in the radiation from B is shifted from the wavelength corresponding to maximum spectral radiance in the radiation from A by 1.00 µm. If the temperature of A is 5802 K,

(A) the temperature of B is 1934 K.
(B) $\lambda_B = 1.5$ µm.
(C) the temperature of B is 11604 K.
(D) the temperature of B is 2901 K.

Q 8. When photons of energy 4.25 eV strike the surface of a metal A, the ejected photoelectrons have maximum kinetic energy $\mathrm{T_A}$ eV and de-Broglie wavelength λ_A. The maximum kinetic energy of photoelectrons liberated from another metal B by photons of energy 4.70 eV is $T_B = (T_A - 1.50\text{ eV})$. If the de-Broglie wavelength of these photoelectrons is $\lambda_B = 2\lambda_A$, then,

(A) the work function of A is 2.25 eV.

(B) the work function of B is 4.20 eV.

(C) $T_A = 2.00$ eV.

(D) $T_B = 2.75$ eV.

Q 9. Which of the following statement(s) is (are) correct?

(A) The rest mass of a stable nucleus is less than the sum of the rest masses of its separated nucleons.

(B) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons.

(C) In nuclear fission, energy is released by fusing two nuclei of medium mass (approximately 100 u).

(D) In nuclear fission, energy is released by fragmentation of a very heavy nucleus.

Q 10. The magnitudes of the gravitational field at distance r_1 and r_2 from the centre of a uniform sphere of radius R and mass M are F_1 and F_2 respectively, then,

(A) $\frac{F_1}{F_2} = \frac{r_1}{r_2}$ if $r_1 < R$ and $r_2 < R$

(B) $\frac{F_1}{F_2} = \frac{r_2^2}{r_1^2}$ if $r_1 > R$ and $r_2 > R$

(C) $\frac{F_1}{F_2} = \frac{r_1^3}{r_2^3}$ if $r_1 < R$ and $r_2 < R$

(D) $\frac{F_1}{F_2} = \frac{r_1^2}{r_2^2}$ if $r_1 < R$ and $r_2 < R$

Q 11. H^+, He^+ and O^{2+} all having the same kinetic energy pass through a region in which there is a uniform magnetic field perpendicular to their velocity. The masses of H^+, He^+ and O^{2+} are 1 u, 4 u and 16 u respectively. Then,

(A) H^+ will be deflected most.
(B) O^{2+} will be deflected most.
(C) He^+ and O^{2+} will be deflected equally.
(D) all will be deflected equally.

Q 12. Two different coils have self-inductances $L_1 = 8\,\mathrm{mH}$ and $L_2 = 2\,\mathrm{mH}$. The current in one coil is increased at a constant rate. The current in the second coil is also increased at the same constant rate. At a certain instant of time, the power given to the two coils is the same. At that time, the current, the induced voltage and the energy stored in the first coil are i_1, V_1 and W_1 respectively. Corresponding values for the second coil at the same instant are i_2, V_2 and W_2 respectively. Then,

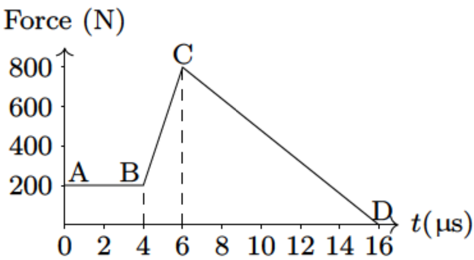
(A) $\frac{i_1}{i_2} = \frac{1}{4}$ (B) $\frac{i_1}{i_2} = 4$ (C) $\frac{W_1}{W_2} = \frac{1}{4}$ (D) $\frac{V_1}{V_2} = 4$

Fill in the Blank Type

This is also part (A) of the paper. There are five fill in the blank type questions in this section. Each question is of two marks.

Q 13. An ideal gas with pressure p, volume V and temperature T is expanded isothermally to a volume $2V$ and a final pressure p_i. If the same gas is expanded adiabatically to a volume $2V$, the final pressure is p_a. The ratio of the specific heats of the gas is 1.67. The ratio p_a/p_i is ......

Q 14. The magnitude of the force (in newton) acting on a body varies with time t (in microseconds) as shown in the figure. AB, BC and CD are straight line segments. The magnitude of the total impulse of the force on the body from $t = 4$ μs to $t = 16$ μs is ...... N s.



Q 15. A bus is moving towards a huge wall with a velocity of 5 m/s. The driver sounds a horn of frequency 200 Hz. The frequency of the beats heard by a passenger of the bus will be …… Hz. [Speed of sound = 342 m/s.]

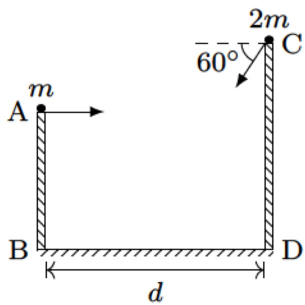
Q 16. An object of mass 0.2 kg executes simple harmonic oscillations along the x-axis with frequency of $25/\pi$ Hz. At the position $x = 0.04$, the object has kinetic energy of 0.5 J and potential energy of 0.4 J. The amplitude of oscillations is...... m.

Q 17. A horizontal pipeline carries water in a streamline flow. At a point along the pipe, where cross-sectional area is 10 cm^2, the water velocity is 1 m/s and the pressure is 2000 Pa. The pressure of water at another point where the cross-sectional area is 5 cm^2, is ...... Pa. [Density of water = 10^3 kg/m^3.]

Descriptive

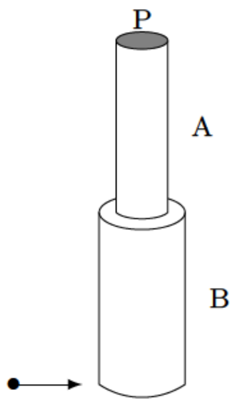
This is part (B) of the paper. There are 12 descriptive questions in this section. Each question is of six marks.

Q 18. Two towers AB and CD are situated a distance d apart as shown in the figure. AB is 20 m high and CD is 30 m high from the ground. An object of mass m is thrown from the top of AB horizontally with a velocity of 10 m/s towards CD. Simultaneously another object of mass $2m$ is thrown from the top of CD at an angle of 60° to the horizontal towards AB with the same magnitude of initial velocity as that of the first object. The two objects move in the same vertical plane, collide in mid-air and stick to each other.

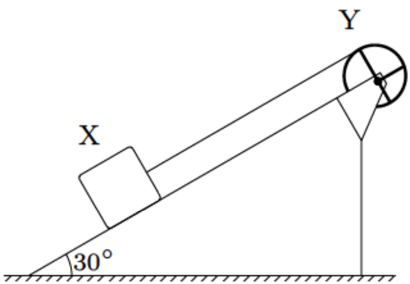


(a) Calculate the distance d between the towers.
(b) Find the position where the objects hit the ground.

Q 19. Two uniform rods A and B of length 0.6 m each and of masses 0.01 kg and 0.02 kg respectively are rigidly joined end to end. The combination is pivoted at the lighter end, P as shown in the figure, such that it can freely rotate about point P in a vertical plane. A small object of mass 0.05 kg, moving horizontally, hits the lower end of the combination and sticks to it. What should be the velocity of the object, so that the system could just be raised to the horizontal position?



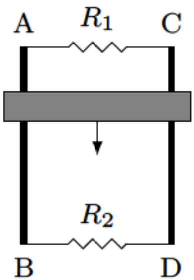
Q 20. A block X of mass 0.5 kg is held by a long massless string on a frictionless inclined plane of inclination $30°$ to the horizontal. The string is wound on a uniform solid cylindrical drum Y of mass 2 kg and of radius 0.2 m as shown in the figure. The drum is given an initial angular velocity such that the block X starts moving up the plane.



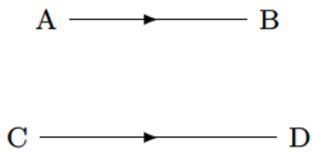
(a) Find the tension in the string during the motion.

(b) At a certain instant of time the magnitude of the angular velocity of Y is 10 rad/s. Calculate the distance travelled by X from that instant of time until it comes to rest.

Q 21. Two parallel vertical metallic rails AB and CD are separated by 1 m. They are connected at two ends by resistances R_1 and R_2 as shown in the figure. A horizontal metallic bar of mass 0.2 kg slides without friction vertically down the rails under the action of gravity. There is a uniform horizontal magnetic field of 0.6 T perpendicular to the plane of the rails. It is observed that when the terminal velocity is attained, the powers dissipated in R_1 and R_2 are 0.76 W and 1.2 W, respectively. Find the terminal velocity of the bar and the values of R_1 and R_2.



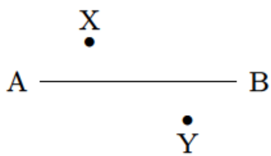
Q 22. A long horizontal wire AB, which is free to move in a vertical plane and carries a steady current of 20 A, is in equilibrium at a height of 0.01 m over another parallel long wire CD which is fixed in a horizontal plane and carries a steady current of 30 A, as shown in the figure. Show that when AB is slightly depressed, it executes SHM. Find the period of oscillations.



Q 23. Two square metal plates of side 1 m are kept 0.01 m apart like a parallel plate capacitor in air in such a way that one of their edges is perpendicular to an oil surface in a tank filled with an insulating oil. The plates are connected to a battery of *emf* 500 V. The plates are then lowered vertically into the oil at a speed of 0.001 m/s. Calculate the current drawn from the battery during the process. [Dielectric constant of oil $= 11$, $\epsilon_0 = 8.85 \times 10^{-12}$ $C^2N^{-1}m^{-2}$.]

Q 24. A metallic rod of length 1 m is rigidly clamped at its mid point. Longitudinal stationary waves are set-up in the rod in such a way that there are two nodes on either side of the mid-point. The amplitude of an antinode is 2×10^{-6} m. Write the equation of motion at a point 2 cm from the mid-point and those of the constituent waves in the rod. [Young's modulus of the material of the rod $= 2 \times 10^{11}$ N/m^2, density $= 8000$ kg/m^3.]

Q 25. An image Y is formed of a point object X by a lens whose optic axis AB is as shown in the figure. Draw a ray diagram to locate the lens and its focus. If the image Y of the object X is formed by a concave mirror (having the same optic axis as AB) instead of lens, draw another ray diagram to locate the mirror and its focus. Write down the steps of construction of the ray diagrams.



Q 26. A closed container of volume $0.02\ \mathrm{m}^3$ contains a mixture of neon and argon gases, at a temperature of $27\ ^\circ\mathrm{C}$ and pressure of $1 \times 10^5\ \mathrm{N/m}^2$. The total mass of the mixture is 28 g. If the molar masses of neon and argon are 20 g/mol and 40 g/mol respectively, find the masses of the individual gases in the container assuming them to be ideal [$R = 8.314$ J/mol K].

Q 27. An ideal gas is taken through a cyclic thermodynamic process through four steps. The amounts of heat involved in these steps are $Q_1 = 5960$ J, $Q_2 = -5585$ J, $Q_3 = -2980$ J and $Q_4 = 3645$ J, respectively. The corresponding quantities of work involved are $W_1 = 2200$ J, $W_2 = -825$ J, $W_3 = -1100$ J and W_4 respectively.

(a) Find the value of W_4.

(b) What is the efficiency of the cycle?

Q 28. A hydrogen like atom (atomic number Z) is in a higher excited state of quantum number n. The excited atom can make a transition to the first excited state by successively emitting two photons of energy 10.2 eV and 17.0 eV respectively. Alternately, the atom from the same excited state can make a transition to the second excited state by successively emitting two photons of energy 4.25 eV and 5.95 eV respectively. Determine the values of n and Z. [Ionization energy of H atom = 13.6 eV.]

Q 29. A small quantity of solution containing Na^{24} radio nuclei (half-life = 15 h) of activity 1.0 μCi is injected into the blood of a person. A sample of the blood of volume 1 cm^3 taken after 5 h shows an activity of 296 disintegration per minute. Determine the total volume of the blood in the body of the person. Assume that the radioactive solution mixes uniformly in the blood of the person. [1 Ci = 3.7×10^{10} disintegration per second.]

Answers

1. A
2. D
3. C
4. B
5. B
6. B
7. A, B
8. A, B, C
9. A, D
10. A, B
11. A, C
12. A, C, D
13. 0.628
14. 5×10^{-3}
15. 6
16. 0.06
17. 500
18. (a) 17.32 m (b) 11.55 m from B
19. 6.3 m/s
20. (a) 1.63 N (b) 1.22 m
21. 1 m/s, $R_1 = 0.47\ \Omega$, $R_2 = 0.3\ \Omega$
22. 0.2 s
23. 4.425×10^{-9} A
24. $y = 2 \times 10^{-6} \sin(0.1\pi) \sin(2500$ $y_1 = 10^{-6} \sin(25000\pi t - 5\pi x)$, $y_2 = 10^{-6} \sin(25000\pi t + 5\pi x)$
25. See solution
26. $m_n = 4.074$ g, $m_a = 23.926$ g
27. (a) 765 J (b) 10.8 %
28. 6, 3
29. 5.95 litre

IIT JEE 1993

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

Paper

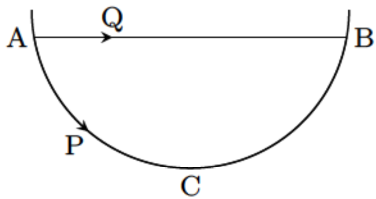
The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) fill in the blank type and (4) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

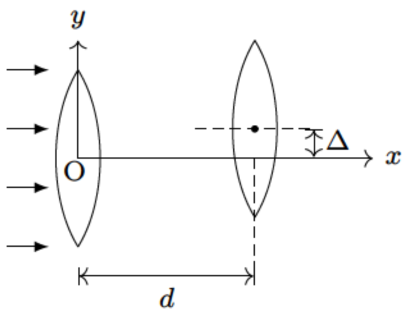
Q 1. A star initially has 10^{40} deuterons. It produces energy via the processes ${}_1\mathrm{H}^2 + {}_1\mathrm{H}^2 \rightarrow {}_1\mathrm{H}^3 + p$ and ${}_1\mathrm{H}^2 + {}_1\mathrm{H}^3 \rightarrow {}_2\mathrm{He}^4 + n$. If the average power radiated by the star is 10^{16} W, the deuteron supply of the star is exhausted in a time of the order of [The nuclei masses are: $m(\mathrm{H}^2) = 2.014$ u; $m(\mathrm{n}) = 1.008$ u; $m(\mathrm{p}) = 1.007$ u; $m(\mathrm{He}^4) = 4.001$ u.]
(A) 10^6 s (B) 10^8 s (C) 10^{12} s (D) 10^{16} s

Q 2. A particle P is sliding down a frictionless hemispherical bowl. It passes the point A at $t = 0$. At this instant of time, the horizontal component of its velocity is v. A bead Q of the same mass as P is ejected from A at $t = 0$ along the horizontal string AB, with the speed v. Friction between the bead and the string may be neglected. Let t_P and t_Q be the respective times taken by P and Q to reach the point B. Then,



(A) $t_P < t_Q$ (B) $t_P = t_Q$
(C) $t_P > t_Q$ (D) $\frac{t_P}{t_Q} = \frac{\text{length of arc ACB}}{\text{length of chord AB}}$

Q 3. Two thin convex lenses of focal lengths f_1 and f_2 are separated by a horizontal distance d (where $d < f_1, d < f_2$) and their centres are displaced by a vertical separation Δ as shown in the figure. Taking the origin of coordinates, O, at the centre of the first lens, the x and y-coordinates of the focal point of this lens system, for a parallel beam of rays coming from the left, are given by



(A) $x = \frac{f_1 f_2}{f_1+f_2}$, $y = \Delta$

(B) $x = \frac{f_1(f_2+d)}{f_1+f_2-d}$, $y = \frac{\Delta^2}{f_1+f_2}$

(C) $x = \frac{f_1 f_2+d(f_1-d)}{f_1+f_2-d}$, $y = \frac{\Delta(f_1-d)}{f_1+f_2-d}$

(D) $x = \frac{f_1 f_2+d(f_1-d)}{f_1+f_2-d}$, $y = 0$

Q 4. Read the following statements carefully,

Y: The resistivity of semiconductor decreases with increase of temperature.

Z: In a conducting solid, the rate of collisions between free electrons and ions increases with increase in temperature.

Select the correct statement(s) from the following.

(A) Y is true but Z is false.
(B) Y is false but Z is true.
(C) Both Y and Z are true.
(D) Y is true and Z is the correct reason for Y.

Q 5. One end of a long metallic wire of length L is tied to the ceiling. The other end is tied to a massless spring of spring constant k. A mass m hangs freely from the free end of the spring. The area of cross-section and the Young's modulus of the wire are A and Y respectively. If the mass is slightly pulled down and released, it will oscillate with a time period T equal to

(A) $2\pi\sqrt{\frac{m}{k}}$ (B) $2\pi\sqrt{\frac{m(YA+kL)}{YAk}}$

(C) $2\pi\sqrt{\frac{mYA}{kL}}$ (D) $2\pi\sqrt{\frac{mL}{YA}}$

Q 6. A current I flows along the length of an infinitely long, straight, thin-walled pipe. Then the magnetic field

(A) at all points inside the pipe is the same, but not zero.
(B) at any point inside the pipe is zero.
(C) is zero only on the axis of the pipe.
(D) is different at different points inside the pipe.

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 7. A particle of mass m moves on the x-axis as follows: it starts from rest at $t = 0$ from the point $x = 0$, and comes to rest at $t = 1$ at the point $x = 1$. No other information is available about its motion at intermediate times $(0 < t < 1)$. If α denotes the instantaneous acceleration of the particle, then,

(A) α cannot remain positive for all t in the interval $0 \leq t \leq 1$.

(B) $|\alpha|$ cannot exceed 2 at any point in its path.

(C) $|\alpha|$ must be ≥ 4 at some point or points in its path.

(D) α must change sign during the motion, but no other assertion can be made with the information given.

Q 8. An ideal gas is taken from the state A (p_0, V_0) to the state B $(\frac{p_0}{2}, 2V_0)$ along a straight line path in the p-V diagram. Select the correct statement(s) from the following,

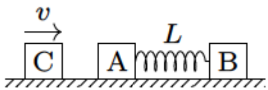
(A) The work done by the gas in the process A to B exceeds the work that would be done if the system were taken from A to B along an isotherm.

(B) In the T-V diagram, the path AB becomes a part of parabola.

(C) In the p-T diagram, the path AB becomes a part of hyperbola.

(D) In going from A to B, the temperature T of the gas first increases to a maximum value and then decreases.

Q 9. Two blocks A and B each of mass m, are connected by a massless spring of natural length L and spring constant k. The blocks are initially resting on a smooth horizontal floor with the spring at its natural length, as shown in the figure. A third identical block C, also of mass m, moves on the floor with a speed v along the line joining A and B, and collides elastically with A. Then,



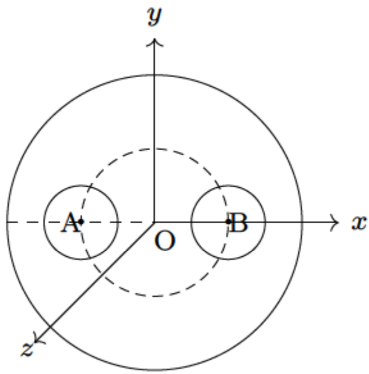
(A) the kinetic energy of the A-B system, at maximum compression of the spring, is zero.

(B) the kinetic energy of the A-B system, at maximum compression of the spring, is $mv^2/4$.

(C) the maximum compression of the spring is $v\sqrt{\frac{m}{k}}$.

(D) the maximum compression of the spring is $v\sqrt{\frac{m}{2k}}$.

Q 10. A solid sphere of uniform density and radius 4 units is located with its centre at the origin O of coordinates. Two spheres of equal radii 1 unit, with their centres at $A(-2, 0, 0)$ and $B(2, 0, 0)$ respectively, are taken out of the solid sphere leaving behind spherical cavities as shown in the figure. Then,



(A) the gravitational field due to this object at the origin is zero.
(B) the gravitational field at the point $B(2, 0, 0)$ is zero.
(C) the gravitational potential is the same at all points on circle $y^2 + z^2 = 36$.
(D) the gravitational potential is the same at all points on circle $y^2 + z^2 = 4$.

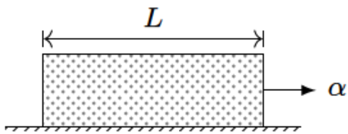
Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

Q 11. In a ...... biased p-n junction, the net flow of holes is from the n region to the p region.

Q 12. A stone of mass m, tied to the end of a string, is whirled around in a horizontal circle. (Neglect the force due to gravity). The length of the string is reduced gradually keeping the angular momentum of the stone about the centre of the circle constant. Then, the tension in the string is given by $T = Ar^n$, where A is a constant, r is the instantaneous radius of the circle. Then $n = \ldots\ldots$

Q 13. A uniform rod of length L and density ρ is being pulled along a smooth floor with a horizontal acceleration α (see figure). The magnitude of the stress at the transverse cross-section through the mid-point of the rod is ......



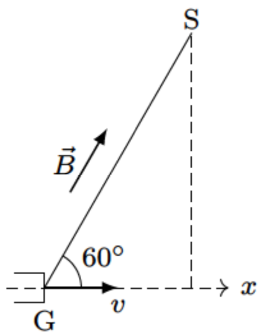
Q 14. In a straight conducting wire, a constant current is flowing from left to right due to a source of *emf*. When the source is switched-off, the direction of the induced current in the wire will be ......

Q 15. A container of volume 1 m^3 is divided into two equal parts by a partition. One part has an ideal gas at 300 K and the other part is vacuum. The whole system is thermally isolated from the surroundings. When the partition is removed, the gas expands to occupy the whole volume. Its temperature will now be ……

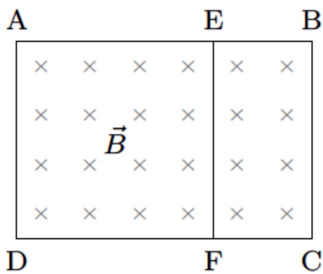
Descriptive

There are descriptive questions in this section. Solve all of them.

Q 16. An electron gun G emits electrons of energy 2 keV travelling in the positive x direction. The electrons are required to hit the spot S where GS = 0.1 m, and the line GS makes an angle of 60° with the x-axis as shown in the figure. A uniform magnetic field $\vec{B}$ parallel to GS exists in the region outside the electron gun. Find the minimum value of B needed to make the electrons hit S.

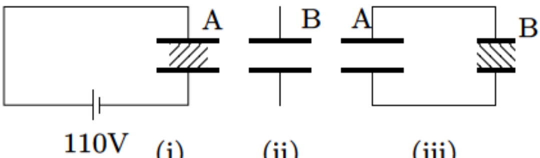


Q 17. A rectangular frame ABCD, made of uniform metal wire, has a straight connection between E and F made of the same wire, as shown in the figure. AEFD is a square of side 1 m and EB = FC = 0.5 m. The entire circuit is placed in a steadily increasing uniform magnetic field directed into the plane of the paper and normal to it. The rate of change of the magnetic field is 1 T/s. The resistance per unit length of the wire is 1 Ω/m. Find the magnitudes and directions of the currents in the segments AE, BE and EF.



Q 18. A circular ring of radius R with uniform positive charge density λ per unit length is located in the y-z plane with its centre at the origin O. A particle of mass m and positive charge q is projected from the point $P(R\sqrt{3}, 0, 0)$ on the positive x-axis directly towards O, with an initial speed v. Find the smallest (non-zero) value of the speed v such that the particle does not return to P.

Q 19. Two parallel plate capacitors A and B have the same separation $d = 8.85 \times 10^{-4}$ m between the plates. The plate areas of A and B are $0.04\ \mathrm{m}^2$ and $0.02\ \mathrm{m}^2$, respectively. A slab of dielectric constant (relative permittivity) $K = 9$ has dimensions such that it can exactly fill the space between the plates of capacitor B.



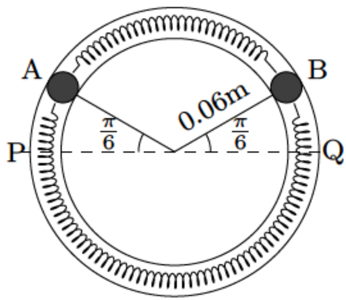
(i) (ii) (iii)

(a) The dielectric slab is placed inside A as shown in the figure (i). A is then charged to a potential difference of 110 V. Calculate the capacitance of A and the energy stored in it.

(b) The battery is disconnected and then the dielectric slab is removed from A. Find the work done by the external agency in removing the slab from A.

(c) The same dielectric slab is now placed inside B, filling it completely. The two capacitors A and B are then connected as shown in the figure (iii). Calculate the energy stored in the system.

Q 20. Two identical balls A and B, each of mass 0.1 kg, are attached to two identical massless springs. The spring-mass system is constrained to move inside a rigid smooth pipe bent in the form of a circle as shown in the figure. The pipe is fixed in a horizontal plane. The centres of the balls can move in a circle of radius 0.06 m. Each spring has a natural length of 0.06π m and spring constant 0.1 N/m. Initially, both the balls are displaced by an angle $\theta = \pi/6$ rad with respect to the diameter PQ of the circle (see figure) and released from rest.



(a) Calculate the frequency of oscillation of ball B.

(b) Find the speed of ball A when A and B are at the two ends of the diameter PQ.

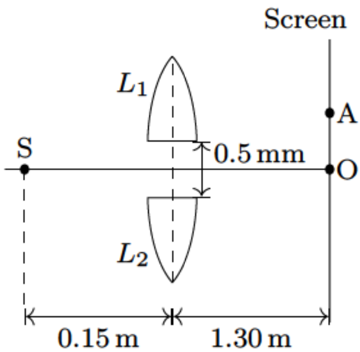
(c) What is the total energy of the system?

Q 21. Two radio stations broadcast their programs at the same amplitude A and at slightly different frequencies ω_1 and ω_2 respectively, where $\omega_1 - \omega_2 = 10^3$ Hz. A detector receives the signals from the two stations simultaneously. It can only detect signals of intensity $\geq 2A^2$.

(a) Find the time interval between successive maxima of the intensity of the signal received by the detector.

(b) Find the time for which the detector remains idle in each cycle of the intensity of the signal.

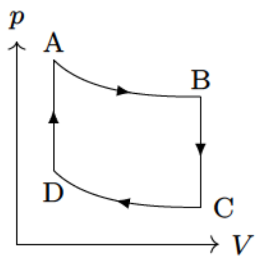
Q 22. In given figure, S is a monochromatic point source emitting light of wavelength $\lambda = 500$ nm. A thin lens of circular shape and focal length 0.10 m is cut into two identical halves L_1 and L_2 by a plane passing through a diameter. The two halves are placed symmetrically about the central axis SO with a gap of 0.5 mm. The distance along the axis from S to L_1 and L_2 is 0.15 m while that from L_1 and L_2 to O is 1.30 m. The screen at O is normal to SO.



(a) If the third intensity maximum occurs at the point A on the screen, find the distance OA.

(b) If the gap between L_1 and L_2 is reduced from its original value of 0.5 mm, will the distance OA increase, decrease, or remain the same.

Q 23. One mole of a monatomic ideal gas is taken through the cycle shown in the figure. $A \to B$ is adiabatic expansion, $B \to C$ is cooling at constant volume, $C \to D$ is adiabatic compression, and $D \to A$ is heating at constant volume. The pressure and temperature at A, B, etc., are denoted by p_A, T_A, p_B, T_B etc., respectively. Given that $T_A = 1000\,\mathrm{K}$, $p_B = \frac{2}{3}p_A$ and $p_C = \frac{1}{3}p_A$, calculate the following quantities, [Given: $(2/3)^{2/5} = 0.85$]



(a) The work done by the gas in the process $A \to B$.
(b) The heat lost by the gas in the process $B \to C$.
(c) The temperature T_D.

Q 24. A uniform thin rod of mass m and length L is standing vertically along the y-axis on a smooth horizontal surface, with its lower end at the origin $(0, 0)$. A slight disturbance at $t = 0$ causes the lower end to slip on the smooth surface along the positive x-axis, and the rod starts falling.

(a) What is the path followed by the centre of mass of the rod during its fall?

(b) Find the equation of the trajectory of a point on the rod located at a distance r from the lower end. What is the shape of the path of this point?

Q 25. A cylindrical solid of mass 10^{-2} kg and cross-sectional area 10^{-4} m^2 is moving parallel to its axis (the x-axis) with a uniform speed of 10^3 m/s in the positive direction. At $t = 0$, its front face passes the plane $x = 0$. The region to the right of this plane is filled with stationary dust particles of density 10^{-3} kg/m^3. When a dust particle collides with the face of cylinder, it sticks to its surface. Assuming that the dimensions of the cylinder remain practically unchanged and that the dust sticks only to the front face of the cylinder find the x-coordinate of the front face of the cylinder at $t = 150$ s.

Q 26. A hemispherical bowl of radius $R = 0.1$ m is rotating about its own axis (which is vertical) with an angular velocity ω. A particle of mass 10^{-2} kg on the frictionless inner surface of the bowl is also rotating with the same ω. The particle is at a height h from the bottom of the bowl.

(a) Obtain the relation between h and ω. What is the minimum value of ω needed, in order to have a non-zero value of h?

(b) It is desired to measure g (acceleration due to gravity) using the set-up by measuring h accurately. Assuming that R and ω are known precisely and that the least count in the measurement of h is 10^{-4} m, what is minimum possible error Δg in the measured value of g?

Q 27. A neutron of kinetic energy 65 eV collides inelastically with a singly ionized helium atom at rest. It is scattered at an angle of 90° with respect to its original direction.

(a) Find the allowed values of the energy of the neutron and that of the atom after collision.

(b) If the atom gets de-excited subsequently by emitting radiation, find the frequencies of the emitted radiation.

[Given: mass of He atom $= 4 \times$ (mass of neutron), ionization energy of H atom $= 13.6$ eV.]

Answers

1. C
2. A
3. C
4. C
5. B
6. B
7. A, C
8. A, B, D
9. B, D
10. A, C, D
11. reverse
12. -3
13. $\frac{1}{2}L\rho\alpha$
14. left to right
15. 300 K
16. 4.73×10^{-3} T
17. $\frac{7}{22}$ A (E $\rightarrow$ A), $\frac{6}{22}$ A (B $\rightarrow$ E), $\frac{1}{22}$ A (F $\rightarrow$ E)
18. $\sqrt{q\lambda/(2\epsilon_0 m)}$
19. (a) 2×10^{-9} F, 1.21×10^{-5} J (b) 4.84×10^{-5} J (c) 1.1×10^{-5} J
20. (a) $\frac{1}{\pi}$ Hz (b) 0.0628 m/s (c) 3.9×10^{-4} J
21. (a) 6.28×10^{-3} s (b) 3.14×10^{-3} s
22. (a) 1 mm (b) increase
23. (a) 1870 J (b) -5300 J (c) 500 K
24. (a) vertical straight line (b) $\frac{x^2}{(L/2-r)^2} + \frac{y^2}{r^2} = 1$, ellipse
25. 10^5 m
26. (a) $h = R - \frac{g}{\omega^2}$, 9.89 rad/s (b) 9.8×10^{-3} m/s^2
27. (a) 6.36 eV, 0.312 eV (of neutron), 17.84 eV, 16.328 eV (of atom) (b) 1.82×10^{1} 1.67×10^{15} Hz, 9.84×10^{15} Hz

IIT JEE 1992

Paper

The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) fill in the blank type and (4) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. A car is moving in a circular horizontal track of radius 10 m with a constant speed of 10 m/s. A plumb bob is suspended from the roof of the car by a light rigid rod. The angle made by the rod with the vertical is [Take $g = 10\ \text{m/s}^2$.]
(A) zero (B) 30° (C) 45° (D) 60°

Q 2. A tube of length L is filled completely with an incompressible liquid of mass M and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. The force exerted by the liquid at the other end is
(A) $\frac{M\omega^2 L}{2}$ (B) $M\omega^2 L$ (C) $\frac{M\omega^2 L}{4}$ (D) $\frac{M\omega^2 L^2}{2}$

Q 3. A highly rigid cubical block A of small mass M and side L is fixed rigidly on to another cubical block B of the same dimensions and of low modulus of rigidity η such that the lower face of A completely covers the upper face of B. The lower face of B is rigidly held on a horizontal surface. A small force F is applied perpendicular to one of the side faces of A. After the force is withdrawn, block A executes small oscillations, the time period of which is given by

(A) $2\pi\sqrt{M\eta L}$ (B) $2\pi\sqrt{\frac{M\eta}{L}}$

(C) $2\pi\sqrt{\frac{ML}{\eta}}$ (D) $2\pi\sqrt{\frac{M}{\eta L}}$

Q 4. Two identical thin rings, each of radius R, are coaxially placed a distance R apart. If Q_1 and Q_2 are respectively the charges uniformly spread on the two rings, the work done in moving a charge q from the centre of one ring to that of the other is

(A) zero (B) $\frac{(\sqrt{2}-1)q(Q_1-Q_2)}{\sqrt{2}(4\pi\epsilon_0 R)}$

(C) $\frac{\sqrt{2}q(Q_1+Q_2)}{4\pi\epsilon_0 R}$ (D) $\frac{(\sqrt{2}+1)q(Q_1+Q_2)}{\sqrt{2}(4\pi\epsilon_0 R)}$

Q 5. Three closed vessels A, B and C are at the same temperature T and contain gases which obey the Maxwellian distribution of velocities. Vessel A contains only O_2, B only N_2, and C a mixture of equal quantities of O_2 and N_2. If the average speed of the O_2 molecules in vessel A is v_1, that of N_2 molecules in vessel B is v_2, the average speed of the O_2 molecules in vessel C is [M is the mass of an O_2 molecule.]

(A) $\frac{v_1+v_2}{2}$ (B) v_1 (C) $\sqrt{v_1 v_2}$ (D) $\sqrt{3kT/M}$

Q 6. The displacement y of a particle executing periodic motion is given by $y = 4\cos^2(t/2)\sin(1000t)$. This expression may be considered to be a result of the superposition of ...... independent harmonic motions.
(A) two (B) three (C) four (D) five

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 7. In an n-p-n transistor circuit, the collector current is 10 mA. If 90% of the electrons emitted reach the collector,

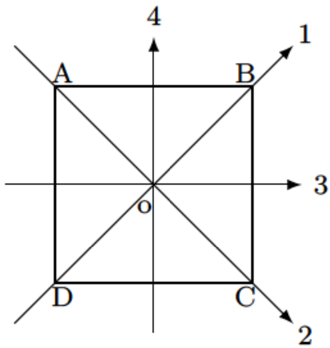
(A) the emitter current will be 9 mA.

(B) the emitter current will be 11 mA.

(C) the base current will be 1 mA.

(D) the base current will be -1 mA.

Q 8. The moment of inertia of a thin square plate ABCD, of uniform thickness about an axis passing through the centre O and perpendicular to the plane of the plate is (where I_1, I_2, I_3 and I_4 are respectively moment of inertia about axes 1, 2, 3 and 4 which are in the plane of the plate.)



(A) $I_1 + I_2$ (B) $I_3 + I_4$
(C) $I_1 + I_3$ (D) $I_1 + I_2 + I_3 + I_4$

Q 9. A planet is observed by an astronomical refracting telescope having an objective of focal length 16 m and an eyepiece of focal length 2 cm,

(A) the distance between the objective and the eyepiece is 16.02 m.

(B) the angular magnification of the planet is -800.

(C) the image of the planet is inverted.

(D) the objective is larger than the eyepiece.

Q 10. When a monochromatic point source of light is at a distance of 0.2 m from a photoelectric cell, the cut-off voltage and the saturation current are 0.6 V and 18.0 mA, respectively. If the same source is placed 0.6 m away from the photoelectric cell, then,

(A) the stopping potential will be 0.2 V.
(B) the stopping potential will be 0.6 V.
(C) the saturation current will be 6.0 mA.
(D) the saturation current will be 2.0 mA.

Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

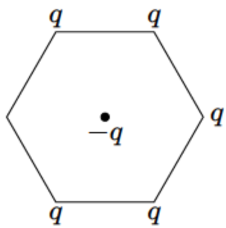
Q 11. The electric potential V at any point x, y, z (all in metre) in space is given by $V = 4x^2$ volt. The electric field at the point $(1\ \text{m}, 0\ \text{m}, 2\ \text{m})$ is ...... V/m.

Q 12. In an X-ray tube, electrons accelerated through a potential difference of $15,000$ V strike a copper target. The speed of the emitted X-ray inside the tube is . . . . . . m/s.

Q 13. In the Bohr model of the hydrogen atom, the ratio of the kinetic energy to the total energy of the electron in a quantum state n is ....

Q 14. In the nuclear process, ${}_6\mathrm{C}^{11} \rightarrow {}_5\mathrm{B}^{11} + \beta^+ + X$, X stands for ....

Q 15. Five point charges, each of value $+q$ coulomb, are placed on five vertices of a regular hexagon of side L metre. The magnitude of the force on the point charge of value $-q$ coulomb placed at the centre of the hexagon is ...... newton.



Q 16. A cylindrical resonance tube open at both ends has fundamental frequency f in air. Half of the length of the tube is dipped vertically in water. The fundamental frequency to the air column now is ......

Q 17. A substance of mass M kg requires a power input of P watts to remain in the molten state at its melting point. When the power source is turned off, the sample completely solidifies in time t seconds. The latent heat of fusion of the substance is ……

Q 18. If ϵ_0 and μ_0 are, respectively, the electric permittivity and magnetic permeability of free space, ϵ and μ the corresponding quantities in a medium, the index of refraction of the medium in terms of the above parameters is ......

Q 19. The resolving power of electron microscope is higher than that of an optical microscope because the wavelength of electron is …… than wavelength of the visible light.

Q 20. A ray of light undergoes deviation of 30° when incident on an equilateral prism of refractive index $\sqrt{2}$. The angle made by the ray inside the prism with the base of the prism is $\ldots\ldots^\circ$.

Descriptive

There are descriptive questions in this section. Solve all of them.

Q 21. Light from discharge tube containing hydrogen atoms falls on the surface of a piece of sodium. The kinetic energy of the fastest photoelectrons emitted from sodium is 0.73 eV. The work function for sodium is 1.82 eV. Find, [Given, ionization potential of hydrogen is 13.6 eV.]

(a) the energy of the photons causing the photoelectrons emission.

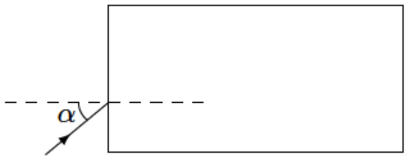
(b) the quantum numbers of the two levels involved in the emission of these photons.

(c) the change in the angular momentum of the electron in the hydrogen atom in the above transition.

(d) the recoil speed of the emitting atom assuming it to be at rest before the transition.

Q 22. A cylindrical block of length $0.4\,\mathrm{m}$ and area of cross-section $0.04\,\mathrm{m}^2$ is placed coaxially on a thin metal disc of mass $0.4\,\mathrm{kg}$ and of the same cross-section. The upper face of the cylinder is maintained at a constant temperature of $400\,\mathrm{K}$ and the initial temperature of the disc is $300\,\mathrm{K}$. If the thermal conductivity of the material of the cylinder is $10\,\mathrm{W\,m^{-1}\,K^{-1}}$ and the specific heat capacity of the material of the disc is $600\,\mathrm{J\,kg^{-1}\,K^{-1}}$, how long will it take for the temperature of the disc to increase to $350\,\mathrm{K}$? Assume, for purpose of calculation, the thermal conductivity of the disc to be very high and the system to be thermally insulated except for the upper face of the cylinder.

Q 23. Light is incident at an angle α on one planar end of a transparent cylindrical rod of refractive index n. Determine the least value of n so that the light entering the rod does not emerge from the curved surface of the rod irrespective of the value of α.



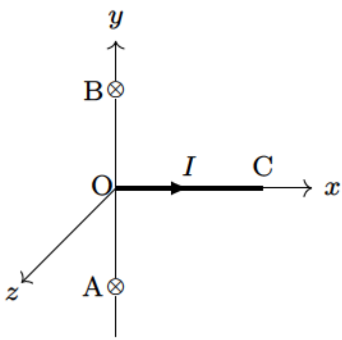
Q 24. Answer the following questions,

(a) A charge Q is uniformly distributed over a spherical volume of radius R. Obtain an expression for the energy of the system.

(b) What will be the corresponding expression for the energy needed to completely disassemble the planet earth against the gravitational pull among its constituent particles? [Assume the earth to be sphere of uniform mass density. Calculate this energy, given the product of the mass and the radius of the earth to be 2.5×10^{31} kg m.]

(c) If the same charge Q as in part (a) is given to a spherical conductor of the same radius R, what will be the energy of the system?

Q 25. A straight segment OC (of length L) of a circuit carrying a current I is placed along the x-axis. Two infinitely long straight wires A and B, each extending from $z = -\infty$ to $+\infty$, are fixed at $y = -a$ and $y = +a$ respectively, as shown in the figure. If the wires A and B each carry a current I into the plane of the paper, obtain the expression for force acting on the segment OC. What will be the force on OC if the current in the wire B is reversed?



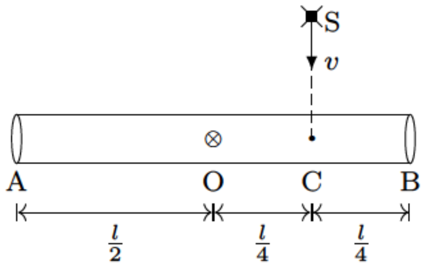
Q 26. A ball of density d is dropped on to a horizontal solid surface. It bounces elastically from the surface and returns to its original position in time t_1. Next, the ball is released and it falls through the same height before striking the surface of density d_L.

(a) If $d < d_L$, obtain an expression (in terms of d, t_1 and d_L) for the time t_2 the ball takes to come back to the position from which it was released.

(b) Is the motion of the ball simple harmonic?

(c) If $d = d_L$, how does the speed of the ball depend on its depth inside the liquid? Neglect all frictional and other dissipative forces. Assume the depth of the liquid to be large.

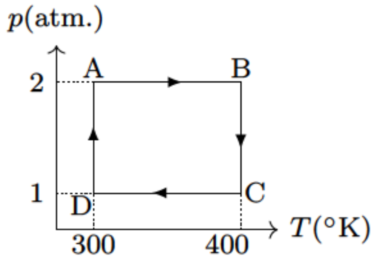
Q 27. A homogeneous rod AB of length $l = 1.8$ m and mass M is pivoted at the centre O in such a way that it can rotate freely in the vertical plane (see figure). The rod is initially in the horizontal position. An insect S of the same mass M falls vertically with speed v on the point C, midway between the points O and B. Immediately after falling, the insect moves towards the end B such that the rod rotates with a constant angular velocity ω.



(a) Determine the angular velocity ω in terms of v and l.

(b) If the insect reaches the end B when the rod has turned through an angle $90°$, determine v.

Q 28. Two moles of helium gas undergo a cyclic process as shown in the figure. Assuming the gas to be ideal, calculate the following quantities in this process.



(a) The net change in the heat energy.
(b) The net work done.
(c) The net change in internal energy.

Answers

1. C
2. A
3. D
4. B
5. B
6. B
7. B, C
8. A, B, C
9. A, B, C, D
10. B, D
11. $-8\hat{\imath}$
12. 3×10^8
13. -1
14. neutrino
15. $9 \times 10^9 \frac{q^2}{L^2}$
16. f
17. $\frac{Pt}{M}$ J/kg
18. $\sqrt{\frac{\mu\epsilon}{\mu_0\epsilon_0}}$
19. smaller
20. zero
21. (a) 2.55 eV (b) $4 \to 2$ (c) $-\frac{h}{\pi}$ (d) 0.814 m/s
22. 166 s
23. $\sqrt{2}$
24. (a) $\frac{3}{20}\frac{Q^2}{\pi\epsilon_0 R}$ (b) $\frac{3}{5}\frac{GM^2}{R}$, 1.5×10^{32} J (c) $\frac{Q^2}{8\pi\epsilon_0 R}$
25. $\vec{F} = -\frac{\mu_0 I^2}{2\pi} \ln\left(\frac{L^2+a^2}{a^2}\right) \hat{\imath}$ zero
26. (a) $\frac{t_1 d_L}{d_L - d}$ (b) no (c) remains same
27. (a) $12v/(7l)$ (b) 3.5 m/s
28. (a) 1152 J (b) 1152 J (c) zero

IIT JEE 1991

Go to IIT JEE 2018 | 2017 | 2016 | 2015 | 2014 | 2013 | 2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001 | 2000 | 1999 | 1998 | 1997 | 1996 | 1995 | 1994 | 1993 | 1992 | 1991 | 1990 | 1989 | 1988 | 1987 | 1986 | 1985 | 1984 | 1983 | 1982 | 1981 | 1980 | 1979 | 1978

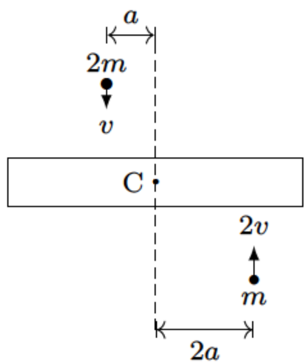
Paper

The paper contains questions of (1) one or more option(s) correct type (2) fill in the blank type and (3) descriptive type.

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 1. A uniform bar of length $6a$ and mass $8m$ lies on a smooth horizontal table. Two point masses m and $2m$ moving in the same horizontal plane with speed $2v$ and v respectively, strike the bar (see figure) and stick to the bar after collision. Denoting angular velocity (about the centre of mass), total energy and centre of mass velocity by ω, E and v_c respectively, we have after collision,



(A) $v_c = 0$ (B) $\omega = \frac{3v}{5a}$ (C) $\omega = \frac{v}{5a}$ (D) $E = \frac{3}{5}mv^2$

Q 2. Two identical straight wires are stretched so as to produce 6 beats/s when vibrating simultaneously. On changing the tension slightly in one of them, the beat frequency remains unchanged. Denoting by T_1 and T_2 the higher and lower initial tension in the strings, then it could be said that while making the above changes in tension

(A) T_2 was decreased (B) T_2 was increased
(C) T_1 was decreased (D) T_1 was increased

Q 3. A microammeter has a resistance of 100 Ω and full scale range of 50 µA. It can be used as a voltmeter or as a higher range ammeter provided a resistance is added to it. Pick the correct range and resistance combination(s),

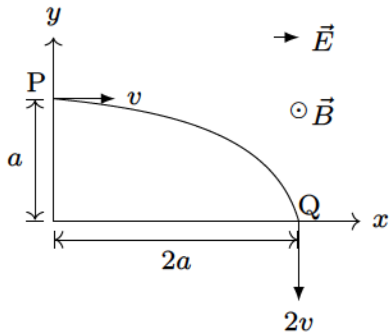
(A) 50 V range with 10 kΩ resistance in series.
(B) 10 V range with 200 kΩ resistance in series.
(C) 5 mA range with 1 Ω resistance in parallel.
(D) 10 mA range with 1 Ω resistance in parallel.

Q 4. A parallel plate capacitor of plate area A and plate separation d is charged to potential difference V and then the battery is disconnected. A slab of dielectric constant K is then inserted between the plates of the capacitor so as to fill the space between the plates. If Q, E and W denote respectively, the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted), and work done on the system in question, in the process of inserting the slab, then,

(A) $Q = \frac{\epsilon_0 AV}{d}$ (B) $Q = \frac{\epsilon_0 KAV}{d}$

(C) $E = \frac{V}{Kd}$ (D) $W = \frac{\epsilon_0 AV^2}{2d}\left[1 - \frac{1}{K}\right]$

Q 5. A particle of charge $+q$ and mass m moving under the influence of a uniform electric field $E\hat{\imath}$ and uniform magnetic field $B\hat{k}$ follows a trajectory from P to Q as shown in figure. The velocities at P and Q are $v\hat{\imath}$ and $-2v\hat{\jmath}$. Which of the following statement(s) is (are) correct?



(A) $E = \frac{3}{4}\left[\frac{mv^2}{qa}\right]$.

(B) Rate of work done by the electric field at P is $\frac{3}{4}\left[\frac{mv^3}{a}\right]$.

(C) Rate of work done by the electric field at P is zero.

(D) Rate of work done by both the fields at Q is zero.

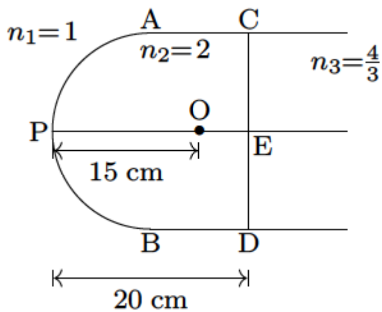
Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

Q 6. A solid copper sphere (density ρ and specific heat c) of radius r at an initial temperature 200 K is suspended inside a chamber whose walls are at almost 0 K. The time required for the temperature of the sphere to drop to 100 K is ......

Q 7. A point source of heat of power P is placed at the centre of a spherical shell of mean radius R. The material of the shell has thermal conductivity K. If the temperature difference between the outer and inner surface of the shell is not to exceed T, the thickness of the shell should not be less than ......

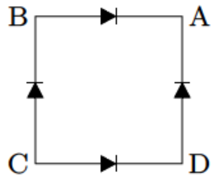
Q 8. A slab of material of refractive index 2, shown in the figure, has a curved surface APB of radius of curvature 10 cm and a plane surface CD. On the left of APB is air and on the right of CD is water with refractive indices as given in the figure. An object O is placed at a distance 15 cm from the pole P as shown. The distance of the final image of O from P, as viewed from left is ......



Q 9. A thin rod of length $f/3$ is placed along the optic axis of a concave mirror of focal length f such that its image, which is real and elongated, just touches the rod. The magnification is ......

Q 10. A piece of metal floats on mercury. The coefficient of volume expansion of the metal and mercury are γ_1 and γ_2, respectively. If the temperatures of both mercury and the metal are increased by an amount ΔT, the fraction of the volume of the metal submerged in mercury changes by the factor ......

Q 11. For the given circuit shown in figure to act as full wave rectifier, the AC input should be connected across ...... and the DC output would appear across ....



Descriptive

There are descriptive questions in this section. Solve all of them.

Q 12. The displacement of the medium in a sound wave is given by the equation $y_i = A\cos(ax + bt)$, where A, a and b are positive constants. The wave is reflected by an obstacle situated at $x = 0$. The intensity of the reflected wave is 0.64 times that of the incident wave.

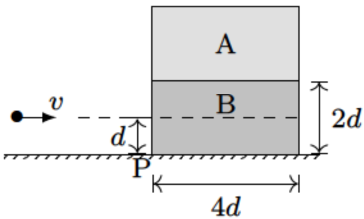
(a) What are the wavelength and frequency of incident wave?

(b) Write the equation for the reflected wave.

(c) In the resultant wave formed after reflection, find the maximum and minimum values of the particle speeds in the medium.

(d) Express the resultant wave as a superposition of a standing wave and a travelling wave. What are the positions of the antinodes of the standing wave? What is the direction of propagation of travelling wave?

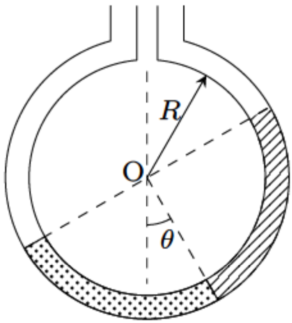
Q 13. A block A of mass $2m$ is placed on another block B of mass $4m$ which in turn is placed on a fixed table. The two blocks have same length $4d$ and they are placed as shown in the figure. The coefficient of friction (both static and kinetic) between the block and table is μ. There is no friction between the two blocks. A small object of mass m moving horizontally along a line passing through the centre of mass (CM) of the block B and perpendicular to its face with a speed v collides elastically with the block B at a height d above the table.



(a) What is the minimum value of v (call it v_0) required to make the block A to topple?

(b) If $v = 2v_0$, find the distance (from the point P in the figure) at which the mass m falls on the table after collision. [Ignore the role of friction during the collision.]

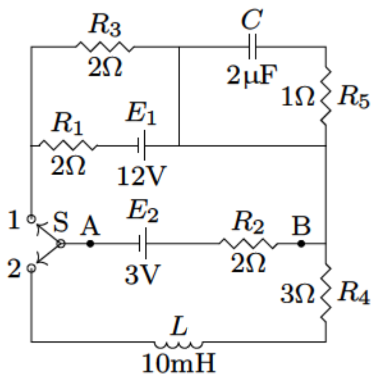
Q 14. Two non-viscous, incompressible and immiscible liquids of densities ρ and 1.5ρ are poured into the two limbs of a circular tube of radius R and small cross-section kept fixed in a vertical plane as shown in the figure. Each liquid occupies one-fourth the circumference of the tube.



(a) Find the angle θ that the radius to the interface makes with the vertical in equilibrium position.

(b) If the whole liquid column is given a small displacement from its equilibrium position, show that the resulting oscillations are simple harmonic. Find the time period of these oscillations.

Q 15. A circuit containing a two position switch S is shown in the figure.



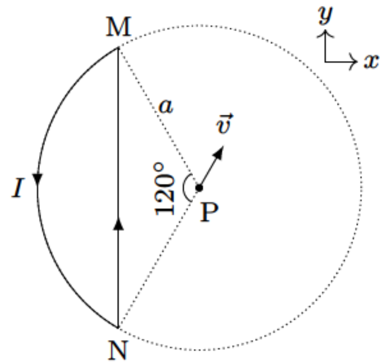
(a) The switch S is in position 1. Find the potential difference $V_A - V_B$ and the rate of production of joule heat in R_1.

(b) If now the switch S is put in position 2 at $t = 0$. Find,

  (i) steady current is R_4.

  (ii) the time when current in R_4 is half the steady value. Also calculate the energy stored in the inductor L at that time.

Q 16. A wire loop carrying a current I is placed in the x-y plane as shown in the figure.



(a) If a particle with charge $+q$ and mass m is placed at the centre P and given a velocity $\vec{v}$ along NP (see figure), find its instantaneous acceleration.

(b) If an external uniform magnetic induction field $\vec{B} = B\hat{\imath}$ is applied, find the force and the torque acting on the loop due to this field.

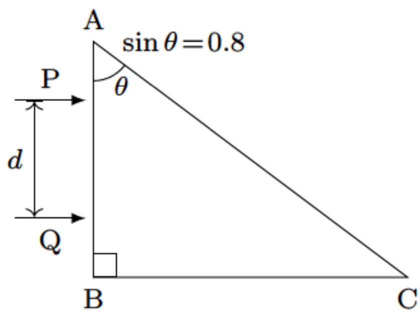
Q 17. Two fixed charges $-2Q$ and Q are located at the points with coordinates $(-3a, 0)$ and $(+3a, 0)$ respectively in the x-y plane.

(a) Show that all points in the x-y plane where the electric potential due to the two charges is zero, lie on a circle. Find its radius and the location of its centre.

(b) Give the expression $V(x)$ at a general point on the x-axis and sketch the function $V(x)$ on the whole x-axis.

(c) If a particle of charge $+q$ starts from rest at the centre of the circle, show by a short quantitative argument that the particle eventually crosses the circle. Find its speed when it does so.

Q 18. Two parallel beams of light P and Q (separation d) containing radiations of wavelengths 4000 Å and 5000 Å (which are mutually coherent in each wavelength separately) are incident normally on a prism as shown in the figure. The refractive index of the prism as a function of wavelength is given by the relation, $\mu(\lambda) = 1.20 + \frac{b}{\lambda^2}$, where λ is in Å and b is a positive constant. The value of b is such that the condition for total internal reflection at the face AC is just satisfied for one wavelength and is not satisfied for the other.



(a) Find the value of b.

(b) Find the deviation of the beams transmitted through the face AC.

(c) A convergent lens is used to bring these transmitted beams into focus. If the intensities of the upper and the lower beams immediately after transmis-

sion from the face AC, are $4I$ and I respectively, find the resultant intensity at the focus.

Q 19. Three moles of an ideal gas $\left(C_p = \frac{7}{2}R\right)$ at pressure p_A and temperature T_A is isothermally expanded to twice its initial volume. It is then compressed at constant pressure to its original volume. Finally, gas is compressed at constant volume to its original pressure p_A.

(a) Sketch p-V and p-T diagrams for the complete process.

(b) Calculate the net work done by the gas, and net heat supplied to the gas during the complete process.

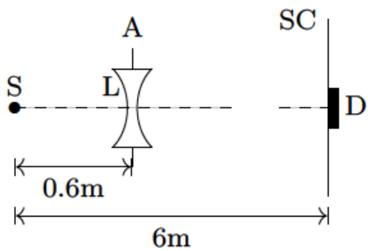
Q 20. A nucleus X, initially at rest, undergoes alpha-decay according to the equation: ${}_{92}^{A}\mathrm{X} \rightarrow {}_{Z}^{228}\mathrm{Y} + \alpha$.

(a) Find the values of A and Z in the above process.

(b) The alpha particle produced in the above process is found to move in a circular track of radius 0.11 m in a uniform magnetic field of 3 T. Find the energy (in MeV) released during the process and the binding energy of the parent nucleus X.

[Given $m\,(Y) = 228.03$ u, $m\left({}_{0}^{1}\mathrm{n}\right) = 1.009$ u, $m\left({}_{2}^{4}\mathrm{He}\right) = 4.003$ u, $m\left({}_{1}^{1}\mathrm{H}\right) = 1.008$ u.]

Q 21. A monochromatic point source S radiating wavelength 6000 Å with power 2 W, an aperture A of diameter 0.1 m and a large screen SC are placed as shown in the figure. A photoemissive detector D of surface area $0.5\ \text{cm}^2$ is placed at the centre of the screen. The efficiency of the detector for the photoelectron generation per incident photon is 0.9.



(a) Calculate the photon flux at the centre of the screen and photocurrent in the detector.

(b) If the concave lens L of focal length 0.6 m is inserted in the aperture as shown, find the new values of photon flux and photocurrent. Assume a uniform average transmission of 80% from the lens.

(c) If the work function of the photoemissive surface is 1 eV, calculate the values of the stopping potential in the two cases (without and with the lens in aperture).

Answers

1. A, C, D

2. B, C

3. B, C

4. A, C, D

5. A, B, D

6. $1.71\rho rc$

7. $\frac{4\pi R^2 KT}{P}$

8. 30 cm to the right of P. Virtual Image.

9. 1.5

10. $\frac{1+\gamma_2\Delta T}{1+\gamma_1\Delta T}$

11. B and D, A and C

12. (a) $2\pi/a$, $b/(2\pi)$ (b) $-0.8A\cos(ax-bt)$ (c) $1.8Ab$, zero (d) $y = -1.6A\sin ax \sin bt + 0.2A\cos(ax + bt)$. Antinodes at $x = \left[n + \frac{(-1)^n}{2}\right]\frac{\pi}{a}$. Negative x direction.

13. (a) $\frac{5}{2}\sqrt{6\mu gd}$ (b) $6d\sqrt{3\mu}$

14. (a) $\tan^{-1}\left(\frac{1}{5}\right)$ (b) $2\pi\sqrt{\frac{1.38R}{g}}$

15. (a) -5 V, 24.5 W (b) (i) 0.6 A (ii) 1.386×10^{-3} s, 4.5×10^{-4} J

16. (a) $\frac{0.11\mu_0 Iqv}{2am}\left(\hat{j} - \sqrt{3}\hat{\imath}\right)$ (b) zero, $0.61Ia^2B\,\hat{j}$

17. (a) $4a$, $(5a, 0)$ (b) $V_x = \frac{Q}{4\pi\epsilon_0}\left(\frac{1}{|3a-x|} -\right.$ (c) $\sqrt{\frac{Qq}{8\pi\epsilon_0 ma}}$

18. (a) $b = 8 \times 10^5$ Å^2 (b) $\delta_1 = 37°, \delta_2 = 27.13°$ (c) $9I$

19. (a) See solution (b) $0.58RT_A$, $0.58RT_A$

20. (a) 232, 90 (b) 5.3 MeV, 1823.2 MeV

21. (a) 2.87×10^{13} s^{-1}m^{-2}, 2.07×10^{-10} A (b) 2.06×10^{13} s^{-1}m^{-2}, 1.483×10^{-10} A (c) 1.06 V in both cases.

IIT JEE 1990

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Paper

The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) fill in the blank type (4) true false type (5) matrix-matching type and (6) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. During paddling of a bicycle, the force of friction exerted by the ground on the two wheels is such that it acts,

(A) in the backward direction on the front wheel and in the forward direction on the rear wheel.

(B) in the forward direction on the front wheel and in the backward direction on the rear wheel.

(C) in the backward direction on both the front and the rear wheels.

(D) in the forward direction on both the front and the rear wheels.

Q 2. A uniform cylinder of length L and mass M having cross-sectional area A is suspended, with its length vertical, from a fixed point by a massless spring, such that it is half-submerged in a liquid of density ρ at equilibrium position. When the cylinder is given a small downward push and released, it starts oscillating vertically with a small amplitude. If the force constant of the spring is k, the frequency of oscillation of the cylinder is

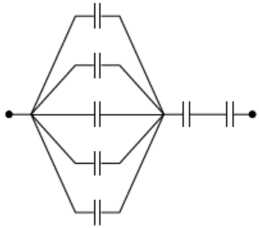
(A) $\frac{1}{2\pi}\left(\frac{k-A\rho g}{M}\right)^{1/2}$ (B) $\frac{1}{2\pi}\left(\frac{k+A\rho g}{M}\right)^{1/2}$

(C) $\frac{1}{2\pi}\left(\frac{k+\rho g L^2}{M}\right)^{1/2}$ (D) $\frac{1}{2\pi}\left(\frac{k+A\rho g}{A\rho g}\right)^{1/2}$

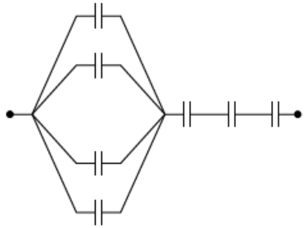
Q 3. When an ideal diatomic gas is heated at constant pressure, the fraction of the heat energy supplied which increases the internal energy of the gas is
(A) 2/5 (B) 3/5 (C) 3/7 (D) 5/7

Q 4. Seven capacitors each of capacitance 2 μF are connected in a configuration to obtain an effective capacitance $\frac{10}{11}$ μF. Which of the following combination will achieve the desired result?

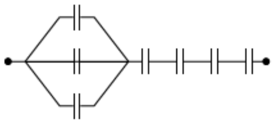
(A)



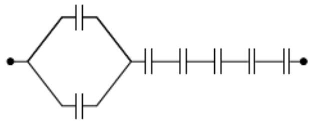
(B)



(C)



(D)



Q 5. A thin prism P_1 with angle $4°$ and made from glass of refractive index 1.54 is combined with another thin prism P_2 made from glass of refractive index 1.72 to produce dispersion without deviation. The angle of the prism P_2 is

(A) $5.33°$ (B) $4°$ (C) $3°$ (D) $2.6°$

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 6. A particle of mass m is projected with a velocity v making an angle of $45°$ with the horizontal. The magnitude of the angular momentum of the projectile about the point of projection when the particle is at its maximum height h is
(A) zero (B) $\frac{mv^3}{4\sqrt{2}g}$ (C) $\frac{mv^3}{\sqrt{2}g}$ (D) $m\sqrt{2gh^3}$

Q 7. A wave is represented by the equation: $y = A \sin(10\pi x + 15\pi t + \pi/3)$, where x is in metre and t is in second. The expression represents

(A) a wave travelling in positive x direction with a velocity 1.5 m/s.

(B) a wave travelling in negative x direction with a velocity 1.5 m/s.

(C) a wave travelling in negative x direction with a wavelength 0.2 m.

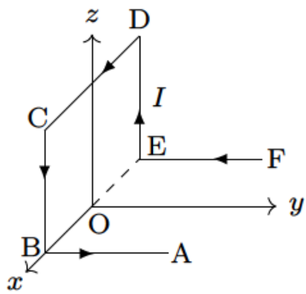
(D) a wave travelling in positive x direction with a wavelength 0.2 m.

Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

Q 8. The amplitude of a wave disturbance travelling in the positive x direction is given by $y = \frac{1}{(1+x)^2}$ at time $t = 0$ and by $y = \frac{1}{1+(x-1)^2}$ at $t = 2\,\mathrm{s}$, where x and y are in metres. The shape of the wave disturbance does not change during the propagation. The velocity of the wave is ...... m/s.

Q 9. A wire ABCDEF (with each side of length L) bent as shown in the figure and carrying a current I is placed in a uniform magnetic induction B parallel to the positive y direction. The force experienced by the wire is ...... in the ...... direction.



Q 10. The wavelength of the characteristic X-ray K_α line emitted by a hydrogen like element is 0.32 Å. The wavelength of the K_β line emitted by the same element will be ......

Q 11. ...... biasing of p-n junction offers high resistance to current flow across the junction. The biasing is obtained by connecting the p-side to the ...... terminal of the battery.

Matrix or Matching Type

This section contains matrix-matching type questions.

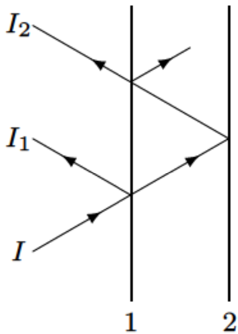
Q 12. *Column I* gives three physical quantities. Select the appropriate units for the choices given in *Column II*. Some of the physical quantities may have more than one choice.

Column I	Column II
(A) Capacitance	(p) ohm-second
(B) Inductance	(q) coulomb^2 (joule)$^{-1}$
(C) Magnetic Induction	(r) coulomb (volt)$^{-1}$
	(s) newton (ampere metre)$^{-1}$
	(t) volt-second (ampere)$^{-1}$

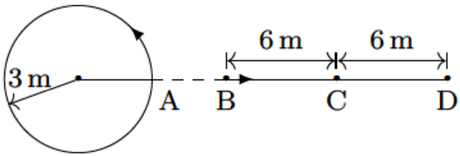
Descriptive

There are descriptive questions in this section. Solve all of them.

Q 13. A narrow monochromatic beam of light of intensity I is incident on a glass plate as shown in the figure. Another identical glass plate is kept close to the first one and parallel to it. Each glass plate reflects 25 per cent of the light incident on it and transmits the remaining. Find the ratio of the minimum and maximum intensities in the interference pattern formed by the two beams obtained after one reflection at each plate.



Q 14. A source of sound is moving along a circular path of radius 3 m with an angular velocity of 10 rad/s. A sound detector located far away from the source is executing linear SHM along the line BD (see figure) with an amplitude BC = CD = 6 m. The frequency of oscillation of the detector is $5/\pi$ Hz. The source is at the point A when the detector is at the point B. If the source emits a continuous sound wave of frequency 340 Hz, find the maximum and the minimum frequencies recorded by the detector. [Speed of sound = 340 m/s.]



Q 15. An ideal gas having initial pressure p, volume V and temperature T is allowed to expand adiabatically until its volume becomes 5.66 V while its temperature falls to $T/2$.

(a) How many degrees of freedom do gas molecules have?

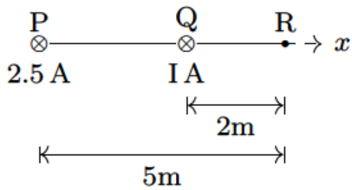
(b) Obtain the work done by the gas during the expansion as a function of the initial pressure p and volume V.

Q 16. Three concentric spherical metallic shells A, B and C of radii a, b and c $(a < b < c)$ have surface charge densities σ, $-\sigma$ and σ, respectively.

(a) Find the potential of the three shells A, B and C.

(b) If the shells A and C are at the same potential, obtain the relation between the radii a, b and c.

Q 17. Two long parallel wires carrying currents 2.5 A and I (ampere) in the same direction (directed into the plane of paper) are held at P and Q respectively such that they are perpendicular to the plane of paper. The points P and Q are located at a distance of 5 m and 2 m respectively from a collinear point R (see figure).



(a) An electron moving with a velocity of 4×10^5 m/s along the positive x direction experiences a force of magnitude 3.2×10^{-20} N at the point R. Find the value of I.

(b) Find all the positions at which a third long parallel wire carrying a current of magnitude 2.5 A may be placed, so that the magnetic induction at R is zero.

Q 18. It is proposed to use the nuclear fusion reaction: ${}^2_1\mathrm{H} + {}^2_1\mathrm{H} \rightarrow {}^4_2\mathrm{He}$, in a nuclear reactor with an electrical power rating of 200 MW. If the energy from the above reaction is used with a 25 percent efficiency in the reactor, how many grams of deuterium fuel will be needed per day? [The masses of ${}^2_1\mathrm{H}$ and ${}^4_2\mathrm{He}$ are 2.0141 u and 4.0026 u, respectively.]

Q 19. An artificial satellite is moving in a circular orbit around the earth with a speed equal to half the magnitude of escape velocity from the earth.

(a) Determine the height of the satellite above the earth's surface.

(b) If the satellite is stopped suddenly in its orbit and allowed to fall freely onto the earth, find the speed with which it hits the surface of the earth.

Q 20. Electrons in hydrogen-like atom ($Z = 3$) make transitions from the fifth to the fourth orbit and from the fourth to the third orbit. The resulting radiations are incident normally on a metal plate and eject photoelectrons. The stopping potential for the photoelectrons ejected by the shorter wavelength is 3.95 V. Calculate the work function of the metal, and the stopping potential for the photoelectrons ejected by the longer wavelength. [Rydberg's constant $= 1.094 \times 10^7$ m^{-1}.]

Q 21. A carpet of mass M made of inextesible material is rolled along its length in the form of a cylinder of radius R and is kept on a rough floor. The carpet starts unrolling without sliding on the floor when negligibly small push is given to it. Calculate the horizontal velocity of the axis of the cylindrical part of the carpet when its radius reduces to $R/2$.

Q 22. An object of mass 5 kg is projected with a velocity of 20 m/s at an angle of $60°$ to the horizontal. At the highest point of its path the projectile explodes and breaks up into two fragments of masses 1 kg and 4 kg. The fragments separate horizontally after the explosion. The explosion releases internal energy such that the kinetic energy of the system at the highest point is doubled. Calculate the separation between the two fragments when they reach the ground.

Answers

1. A
2. B
3. D
4. A
5. C
6. B, D
7. B, C
8. 1
9. ILB, +ve z
10. 0.27 Å
11. reverse, negative
12. A$\mapsto$(q,r), B$\mapsto$(p,t), C$\mapsto$s
13. 1/49
14. 438.7 Hz, 257.3 Hz
15. (a) 5 (b) $1.25pV$
16. (a) $V_A = \frac{\sigma}{\epsilon_0}(a-b+c)$, $V_B = \frac{\sigma}{\epsilon_0}\left(\frac{a^2}{b}-b+c\right)$, $V_C = \frac{\sigma}{\epsilon_0}\left(\frac{a^2-b^2+c^2}{c}\right)$ (b) $a+b=c$
17. (a) 4 A (b) $x = \pm 1$ m w.r.t. R.
18. 120 g
19. (a) 6400 km (b) 7.9 km/
20. 2 eV, 0.754 eV
21. $\sqrt{14Rg/3}$
22. 44.25 m

IIT JEE 1989

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Paper

The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) fill in the blank type (4) true false type and (5) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. The decay constant of a radioactive sample is λ. The half-life and mean-life of the sample are respectively given by

(A) $1/\lambda$ and $(\ln 2)/\lambda$ (B) $(\ln 2)/\lambda$ and $1/\lambda$

(C) $\lambda(\ln 2)$ and $1/\lambda$ (D) $\lambda/(\ln 2)$ and $1/\lambda$

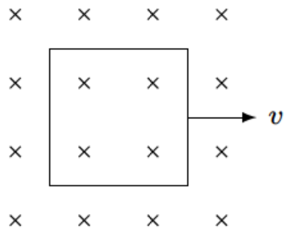
Q 2. Imagine a light planet revolving around a very massive star in a circular orbit of radius R with a period of revolution T. If the gravitational force of attraction between the planet and the star is proportional to $R^{-5/2}$, then,

(A) $T^2 \propto R^2$ (B) $T^2 \propto R^{7/2}$

(C) $T^2 \propto R^{3/2}$ (D) $T^2 \propto R^{3.75}$

Q 3. Two rods of different materials having coefficients of thermal expansion α_1, α_2 and Young's modulii Y_1, Y_2 respectively are fixed between two rigid massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of the rods. If $\alpha_1 : \alpha_2 = 2 : 3$, the thermal stresses developed in the two rods are equal provided $Y_1 : Y_2$ is equal to
(A) $2:3$ (B) $1:1$ (C) $3:2$ (D) $4:9$

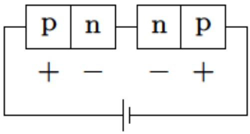
Q 4. A conducting square loop of side L and resistance R moves in its plane with a uniform velocity v perpendicular to one of its sides. A magnetic induction B, constant in time and space, pointing perpendicular to and into the plane of the loop exists everywhere. The current induced in the loop is



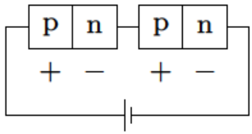
(A) BLv/R clockwise
(B) BLv/R anticlockwise
(C) $2BLv/R$ anticlockwise
(D) zero

Q 5. A solid conducting sphere having a charge Q is surrounded by an uncharged concentric conducting hollow spherical shell. Let the potential difference between the surface of the solid sphere and that of the outer surface of the hollow shell be V. If the shell is given a charge of $-3Q$, the new potential difference between the same two surfaces is
(A) V (B) $2V$ (C) $4V$ (D) $-2V$

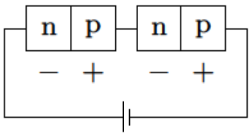
Q 6. Two identical p-n junctions may be connected in series with a battery in three ways. The potential drops across the two p-n junction are equal in



Circuit-1



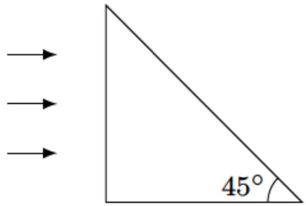
Circuit-2



Circuit-3

(A) circuit-1 and circuit-2
(B) circuit-2 and circuit-3
(C) circuit-3 and circuit-1
(D) circuit-1 only

Q 7. A beam of light consisting of red, green and blue colours is incident on a right-angled prism. The refractive indices of the material of the prism for the above red, green, and blue wavelengths are 1.39, 1.44 and 1.47, respectively. The prism will



(A) separate the red colour from the green and blue colours.
(B) separate the blue colour from the red and green colours.
(C) separate all the three colours from one another.
(D) not separate even partially any colour from the other two colours.

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 8. Capacitor C_1 of capacitance 1 μF and capacitor C_2 of capacitance 2 μF are separately charged fully by a common battery. The two capacitors are then separately allowed to discharge through equal resistors at time $t = 0$.

(A) The current in each of the two discharging circuits is zero at $t = 0$.

(B) The currents in the two discharging circuits at $t = 0$ are equal but not zero.

(C) The currents in the two discharging circuits at $t = 0$ are unequal.

(D) Capacitor C_1 loses 50% of its initial charge sooner than C_2 loses 50% of its initial charge.

Q 9. A linear harmonic oscillator of force constant 2×10^6 N/m and amplitude 0.01 m has a total mechanical energy of 160 J. Its

(A) maximum potential energy is 100 J.

(B) maximum kinetic energy is 100 J.

(C) maximum potential energy is 160 J.

(D) maximum potential energy is zero.

Q 10. Velocity of sound in air is 320 m/s. A pipe closed at one end has a length of 1 m. Neglecting end corrections, the air column in the pipe can resonate for sound of frequency

(A) 80 Hz (B) 240 Hz (C) 320 Hz (D) 400 Hz

Q 11. An astronomical telescope has an angular magnification of magnitude 5 for distant objects. The separation between the objective and the eyepiece is 36 cm and the final image is formed at infinity. The focal length f_o of the objective and the focal length f_e of the eyepiece are

(A) $f_o = 45$ cm, $f_e = -9$ cm
(B) $f_o = 50$ cm, $f_e = 10$ cm
(C) $f_o = 7.2$ cm, $f_e = 5$ cm
(D) $f_o = 30$ cm, $f_e = 6$ cm

Q 12. For an ideal gas,

(A) the change in internal energy in a constant pressure process from temperature T_1 to T_2 is equal to $nC_V(T_2 - T_1)$, where C_V is the molar heat capacity at constant volume and n the number of moles of the gas.

(B) the change in internal energy of the gas and the work done by the gas are equal in magnitude in an adiabatic process.

(C) the internal energy does not change in an isothermal process.

(D) no heat is added or removed in an adiabatic process.

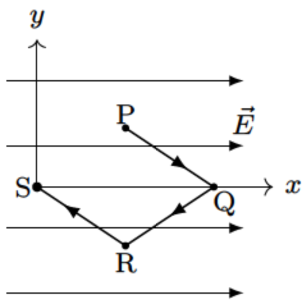
Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

Q 13. A point source emits sound equally in all directions in a non-absorbing medium. Two points P and Q are at a distance 9 m and 25 m respectively from the source. The ratio of amplitudes of the waves at P and Q is ......

Q 14. A uniformly wound solenoid coil of self-inductance 1.8×10^{-4} H and resistance $6\,\Omega$ is broken up into two identical coils. These identical coils are then connected in parallel across a 15 V battery of negligible resistance. The time constant for the current in the circuit is ...... s and the steady state current through the battery is ...... A.

Q 15. A point charge q moves from point P to point S along the path PQRS (see figure) in a uniform electric field E pointing parallel to the positive direction of the x-axis. The coordinates of points P, Q, R and S are $(a, b, 0)$, $(2a, 0, 0)$, $(a, -b, 0)$, $(0, 0, 0)$ respectively. The work done by the field in the above process is given by the expression ......



Q 16. 300 g of water at 25 °C is added to 100 g of ice at 0 °C. The final temperature of the mixture is . . . . . . °C.

Q 17. The earth receives at its surface radiation from the sun at the rate of $1400\ \mathrm{W/m^2}$. The distance of the centre of the sun from the earth is 1.5×10^{11} m and the radius of the sun is 7×10^{8} m. Treating the sun as a black body, it follows from the above data that its surface temperature is $\ldots\ldots$K.

True False Type

This section contains true false type questions.

Q 18. Two particles of mass 1 kg and 3 kg move towards each other under their mutual force of attraction. No other force acts on them. When the relative velocity of approach of the two particles is 2 m/s, their centre of mass has a velocity of 0.5 m/s. When the relative velocity of approach becomes 3 m/s, the velocity of the centre of mass is 0.75 m/s.

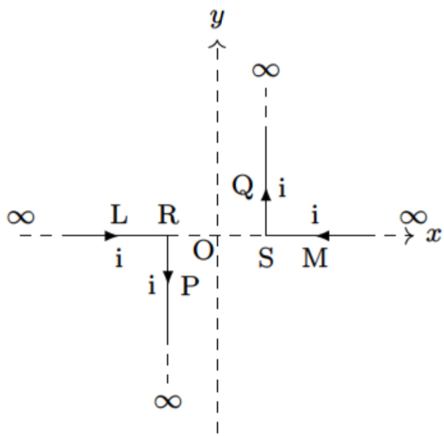
Q 19. A ring of mass 0.3 kg and radius 0.1 m and a solid cylinder of mass 0.4 kg and of the same radius are given the same kinetic energy and released simultaneously on a flat horizontal surface such that they begin to roll as soon as released towards a wall which is at the same distance from the ring and the cylinder. The rolling friction in both cases is negligible. The cylinder will reach the wall first.

Q 20. The order of magnitude of the density of nuclear matter is 10^4 kg/m^3.

Descriptive

There are descriptive questions in this section. Solve all of them.

Q 21. A pair of stationary and infinitely long bent wires are placed in the x-y plane as shown in the figure. The wires carry current of $i = 10$ A each as shown. The segment L and M are along the x-axis. The segment P and Q are parallel to the y-axis such that OS = OR = 0.02 m. Find the magnitude and direction of the magnetic induction at the origin O.



Q 22. A gas of identical hydrogen-like atoms has some atoms in the lowest (ground) energy level A and some atoms in a particular upper (excited) energy level B and there are no atoms in any other energy level. The atoms of the gas make the transition to a higher energy level by absorbing monochromatic light of photon energy 2.7 eV. Subsequently, the atoms emit radiation of only six different energy photons. Some of the emitted photons have an energy of 2.7 eV, some have more energy and some less than 2.7 eV.

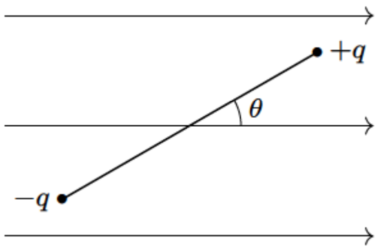
(a) Find the principal quantum number of the initially excited level B.

(b) Find the ionization energy of the gas atoms.

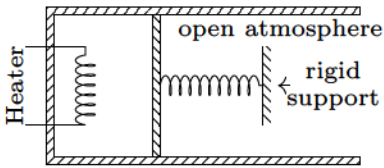
(c) Find the maximum and the minimum energies of the emitted photons.

Q 23. A beam of light has three wavelengths 4144 Å, 4972 Å and 6216 Å with a total energy of 3.6×10^{-3} W/m^2 equally distributed amongst the three wavelengths. The beam falls normally on an area 1 cm^2 of a clean metallic surface of work function 2.3 eV. Assume that there is no loss of light by reflection and that each energetically capable photon ejects one electron. Calculate the number of photoelectrons liberated in two seconds.

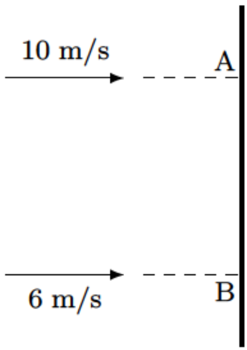
Q 24. A point particle of mass M attached to one end of a massless rigid non-conducting rod of length L. Another point particle of the same mass is attached to the other end of the rod. The two particles carry charges $+q$ and $-q$ respectively. This arrangement is held in a region of a uniform electric field E such that the rod makes a small angle θ (say about 5°) with the field direction as shown in the figure. Find the expression for the minimum time needed for the rod to become parallel to the field after it is set free.



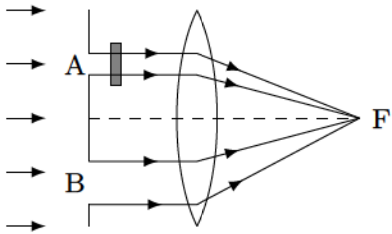
Q 25. An ideal monatomic gas is confined in a cylinder by a spring loaded piston of cross-section 8.0×10^{-3} m^2. Initially, the gas is at 300 K and occupies a volume of 2.4×10^{-3} m^3 and the spring is in its relaxed (unstretched, uncompressed) state. The gas is heated by a small electric heater until the piston moves out slowly by 0.1 m. Calculate the final temperature of the gas and the heat supplied (in Joules) by the heater. [The force constant of the spring is 8000 N/m, and the atmospheric pressure 1.0×10^5 Nm^{-2}. The cylinder and the piston are thermally insulated. The piston is massless and there is no friction between the piston and the cylinder. Neglect heat loss through the lead wires of the heater. The heat capacity of the heater coil is negligible. Assume the spring to be massless.]



Q 26. A thin uniform bar lies on a frictionless horizontal surface and is free to move in any way on the surface. Its mass is 0.16 kg and length is $\sqrt{3}$ m. Two particles, each of mass 0.08 kg are moving on the same surface towards the bar one with a velocity of 10 m/s and the other with 6 m/s, as shown in the figure. The first particle strikes the bar at point A and the other at point B. Points A and B are at a distance of 0.5 m from the centre of the bar. The particles strike the bar at the same instant of time and stick to the bar on collision. Calculate the loss of kinetic energy of the system in the above collision process.



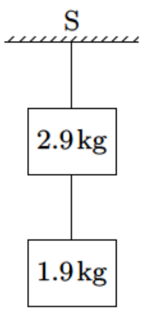
Q 27. In a modified Young's double slit experiment, a monochromatic uniform and parallel beam of light of wavelength 6000 Å and intensity $10/\pi$ W/m^2 is incident normally on two apertures A and B of radii 0.001 m and 0.002 m respectively. A perfectly transparent film of thickness 2000 Å and refractive index 1.5 for the wavelength of 6000 Å is placed in front of aperture A (see figure). Calculate the power (in W) received at the focal spot F of the lens. The lens is symmetrically placed with respect to the apertures. Assume that 10% of the power received by each aperture goes in the original direction and is brought to the focal spot.



Q 28. Two blocks of mass 2.9 kg and 1.9 kg are suspended from a rigid support S by two inextensible wires each of length 1 m (see figure). The upper wire has negligible mass and the lower wire has a uniform mass of 0.2 kg/m. The whole system of blocks, wire and support have an upward acceleration of 0.2 m/s^2. [Take $g = 9.8$ m/s^2.]

(a) Find the tension at the midpoint of the lower wire.

(b) Find the tension at the midpoint of the upper wire.



Answers

1. B
2. B
3. C
4. D
5. A
6. B
7. A
8. B, D
9. B, C
10. A, B, D
11. A, D
12. A, B, C, D
13. 25/9
14. 3×10^{-5}, 10
15. $-qEa$
16. 0 °C
17. 5803
18. F
19. F
20. F
21. $10^{-4}\,\hat{\mathrm{k}}$ T
22. (a) 2 (b) 14.4 eV
    (c) 13.5 eV, 0.7 eV
23. 1.1×10^{12}
24. $\frac{\pi}{2}\sqrt{\frac{ML}{2qE}}$
25. 800 K, 720 J
26. 2.72 J
27. 7×10^{-6} W
28. (a) 20 N (b) 50 N

IIT JEE 1988

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Paper

The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) fill in the blanks type (4) true false type and (5) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. A freshly prepared radioactive source of half-life 2 h emits radiation of intensity which is 64 times the permissible safe level. The minimum time after which it would be possible to work safely with this source is
(A) 6 h (B) 12 h (C) 24 h (D) 128 h

Q 2. A boat, which has a speed of 5 km/h in still water, crosses a river of width 1 km along the shortest possible path in 15 min. The velocity of the river water (in km/h) is
(A) 1 (B) 3 (C) 4 (D) $\sqrt{41}$

Q 3. Two bodies M and N of equal masses are suspended from two separate massless springs of spring constants k_1 and k_2 respectively. If the two bodies oscillate vertically such that their maximum velocities are equal, the ratio of the amplitude of vibration of M to that of N is
(A) k_1/k_2 (B) $\sqrt{k_2/k_1}$ (C) k_2/k_1 (D) $\sqrt{k_1/k_2}$

Q 4. A vessel contains oil (density $= 0.8\,\mathrm{g/cm^3}$) over mercury (density $= 13.6\,\mathrm{g/cm^3}$). A homogeneous sphere floats with half its volume immersed in mercury and the other half in oil. The density of the material of the sphere (in $\mathrm{g/cm^3}$) is

(A) 3.3 (B) 6.4 (C) 7.2 (D) 12.8

Q 5. Two particles X and Y having equal charges, after being accelerated through the same potential difference, enter a region of uniform magnetic field and describe circular paths of radii R_1 and R_2 respectively. The ratio of the mass of X to that of Y is

(A) $(R_1/R_2)^{1/2}$ (B) R_2/R_1

(C) $(R_1/R_2)^2$ (D) R_1/R_2

Q 6. If one mole of a monatomic gas ($\gamma = 5/3$) is mixed with one mole of a diatomic gas ($\gamma = 7/5$), the value of γ for the mixture is
(A) 1.40 (B) 1.50 (C) 1.53 (D) 3.07

Q 7. A cylinder of radius R made of a material of thermal conductivity K_1 is surrounded by a cylindrical shell of inner radius R and outer radius $2R$ made of material of thermal conductivity K_2. The two ends of the combined system are maintained at two different temperatures. There is no loss of heat across the cylindrical surface and the system is in steady state. The effective thermal conductivity of the system is
(A) $K_1 + K_2$ (B) $\frac{K_1K_2}{K_1+K_2}$ (C) $\frac{K_1+3K_2}{4}$ (D) $\frac{3K_1+K_2}{4}$

Q 8. A piece of copper and another of germanium are cooled from room temperature to 80 K. The resistance of

(A) each of them increases.
(B) each of them decreases.
(C) copper increases and germanium decreases.
(D) copper decreases and germanium increases.

Q 9. An organ pipe P_1, closed at one end and vibrating in its first harmonic, and another pipe P_2, open at both ends and vibrating in its third harmonic, are in resonance with a given tuning fork. The ratio of the length of P_1 to that of P_2 is
(A) 8/3 (B) 3/8 (C) 1/6 (D) 1/3

Q 10. Two coherent monochromatic light beams of intensities I and $4I$ are superposed. The maximum and minimum possible intensities in the resulting beam are

(A) $5I$ and I (B) $5I$ and $3I$
(C) $9I$ and I (D) $9I$ and $3I$

Q 11. A short linear object of length b lies along the axis of a concave mirror of focal length f at a distance u from the pole of the mirror. The size of the image is approximately equal to,

(A) $b\left(\frac{u-f}{f}\right)^{1/2}$ (B) $b\left(\frac{f}{u-f}\right)^{1/2}$

(C) $b\left(\frac{u-f}{f}\right)^{2}$ (D) $b\left(\frac{f}{u-f}\right)^{2}$

Q 12. A wave represented by the equation $y = a\cos(kx - \omega t)$ is superimposed with another wave to form a stationary wave such that point $x = 0$ is a node. The equation for the other wave is

(A) $a\sin(kx + \omega t)$ (B) $-a\cos(kx - \omega t)$
(C) $-a\cos(kx + \omega t)$ (D) $-a\sin(kx - \omega t)$

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 13. The potential difference applied to an X-ray tube is increased. As a result, in the emitted radiation,
(A) the intensity increases.
(B) the minimum wavelength increases.
(C) the intensity remains unchanged.
(D) the minimum wavelength decreases.

Q 14. The impurity atoms with which pure silicon should be doped to make a p-type semiconductor are those of

(A) phosphorus (B) boron
(C) antimony (D) aluminium

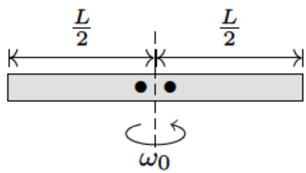
Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

Q 15. Two parallel plate capacitors of capacitance C and $2C$ are connected in parallel and charged to a potential difference V. The battery is then disconnected and the region between the plates of capacitor C is completely filled with a material of dielectric constant K. The potential difference across the capacitors now becomes ......

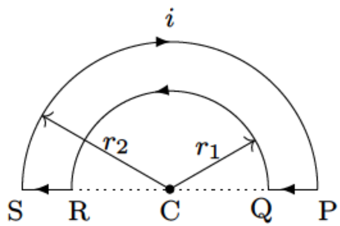
Q 16. A cylinder of mass M and radius R is resting on a horizontal platform (which is parallel to the x-y plane) with its axis fixed along the y-axis and free to rotate about its axis. The platform is given a motion in the x direction given by $x = A\cos\omega t$. There is no slipping between the cylinder and platform. The maximum torque acting on the cylinder during its motion is $\ldots\ldots$

Q 17. A smooth uniform rod of length L and mass M has two identical beads of negligible size, each of mass m, which can slide freely along the rod. Initially the two beads are at the centre of the rod and the system is rotating with an angular velocity ω_0 about an axis perpendicular to the rod and passing through the mid-point of the rod (see figure). There are no external forces. When the beads reach the ends of the rod, the angular velocity of the system is ......



Q 18. In a hydrogen atom, the electron moves in an orbit of radius 0.5 Å making 10^{16} revolutions per second. The magnetic moment associated with the orbital motion of the electron is ......

Q 19. The wire loop $PQRSP$ formed by joining two semicircular wires of radii r_1 and r_2 carries current i as shown in the figure. The magnitude of the magnetic induction at the centre C is ......



Q 20. In the forward bias arrangement of p-n junction rectifier, the p end is connected to the ...... terminal of the battery and the direction of the current is from ...... to ...... in the rectifier.

Q 21. A solid sphere of radius R made of a material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area A floats on the surface of the liquid. When a mass M is placed on the piston to compress the liquid the fractional change in the radius of the sphere, $\Delta R/R$, is ……

Q 22. The binding energies per nucleon for deuteron $\left({}_1H^2\right)$ and helium $\left({}_2He^4\right)$ are 1.1 MeV and 7.0 MeV respectively. The energies released when two deuterons fuse to form helium nucleus $\left({}_2He^4\right)$ is ....

Q 23. The masses and radii of the Earth and the Moon are M_1, R_1 and M_2, R_2 respectively. Their centres are at a distance d apart. The minimum speed with which a particle of mass m should be projected from a point midway between the two centres so as to escape to infinity is ......

True False Type

This section contains true false type questions.

Q 24. A parallel beam of white light falls on a combination of a concave and a convex lens, both of the same material. Their focal lengths are 15 cm and 30 cm respectively for the mean wavelength in white light. On the same side of the lens system, one sees coloured patterns with violet colour at the outer edge.

Q 25. An electric line of force in the x-y plane is given by the equation $x^2 + y^2 = 1$. A particle with unit positive charge, initially at rest at the point $x = 1$, $y = 0$ in the x-y plane, will move along the circular line of force.

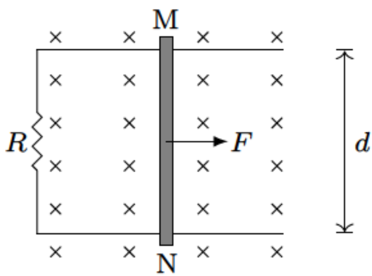
Q 26. A ring of radius R carries a uniformly distributed charge $+Q$. A point charge $-q$ is placed on the axis of the ring at a distance $2R$ from the centre of the ring and released from rest. The particle executes a SHM along the axis of the ring.

Q 27. Two spheres of the same material have radii 1 m and 4 m, temperature 4000 K and 2000 K respectively. The energy radiated per second by the first sphere is greater than that by the second.

Descriptive

There are descriptive questions in this section. Solve all of them.

Q 28. Two long parallel horizontal rails, a distance d apart and each having a resistance λ per unit length, are joined at one end by a resistance R. A perfectly conducting rod MN of mass m is free to slide along the rails without friction (see figure). There is a uniform magnetic field of induction B normal to the plane of the paper and directed into the paper. A variable force F is applied to the rod MN such that, as the rod moves, a constant current i flows through R. Find (a) the velocity of the rod and the applied force F as functions of the distance x of the rod from R, and (b) fraction of the work done per second by F converted to heat.



Q 29. A parallel beam of light travelling in water (refractive index $= 4/3$) is refracted by a spherical air bubble of radius 2 mm situated in water. Assuming the light rays to be paraxial,

(a) Find the position of the image due to refraction at the first surface and the position of the final image.

(b) Draw a ray diagram showing the positions of both the images.

Q 30. A bullet of mass m is fired with a velocity 50 m/s at an angle θ with the horizontal. At the highest point of its trajectory, it collides head-on with a bob of mass $3m$ suspended by a massless string of length 10/3 m and gets embedded in the bob. After the collision the string moves through an angle of 120°. Find, [Take $g = 10\ \text{m/s}^2$.]

(a) the angle θ.

(b) the vertical and horizontal coordinates of the initial position of the bob with respect to the point of firing of the bullet.

Q 31. Three particles, each of mass m, are situated at the vertices of an equilateral triangle of side length a. The only force acting on the particles are their mutual gravitational forces. It is desired that each particle moves in a circle while maintaining the original mutual separation a. Find the initial velocity that should be given to each particle and also the time period of the circular motion.

Q 32. A particle of charge equal to that of an electron, $-e$, and mass 208 times of the mass of the electron (called a mu-meson) moves in a circular orbit around a nucleus of charge $+3e$. Assuming that the Bohr model of the atom is applicable to this system, [Take the mass of the nucleus to be infinite and Rydberg's constant $= 1.097 \times 10^{7}\ \mathrm{m}^{-1}$.]

(a) derive the expression for the radius of the n^{th} Bohr orbit.

(b) find the value of n for which the radius of the orbit is approximately the same as that of the first Bohr orbit for the hydrogen atom.

(c) find the wavelength of the radiation emitted when the mu-meson jumps from the third orbit to the first orbit.

Q 33. Three particles, each of mass 1 g and carrying a charge q, are suspended from a common point by insulated massless strings, each 100 cm long. If the particles are in equilibrium and are located at the corners of an equilateral triangle of side length 3 cm, calculate the charge q on each particle. [Take $g = 10\ \mathrm{m/s^2}$.]

Q 34. Two moles of helium gas ($\gamma = 5/3$) are initially at temperature 27 °C and occupy a volume of 20 litre. The gas is first expanded at constant pressure until the volume is doubled. Then it undergoes an adiabatic change until the temperature returns to its initial value.

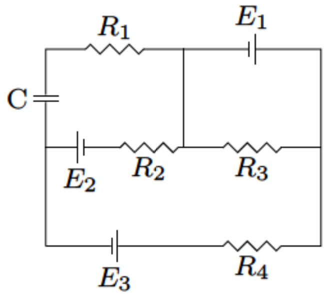
(a) Sketch the process on a p-V diagram.
(b) What are the final volume and pressure of the gas?
(c) What is the work done by the gas?

Q 35. A train approaching a hill at a speed of 40 km/h sounds a whistle of frequency 580 Hz when it is at a distance of 1 km from the hill. A wind with a speed of 40 km/h is blowing in the direction of motion of the train. Find, [Velocity of sound = 1200 km/h.]

(a) the frequency of the whistle as heard by an observer on the hill.

(b) the distance from the hill at which the echo from the hill is heard by the driver and its frequency.

Q 36. In the given circuit: $E_1 = 3E_2 = 2E_3 = 6\,\text{V}$ and $R_1 = 2R_4 = 6\,\Omega$, $R_3 = 2R_2 = 4\,\Omega$, $C = 5\,\mu\text{F}$. Find the current in R_3 and the energy stored in the capacitor.



Answers

1. B
2. B
3. B
4. C
5. C
6. B
7. C
8. D
9. C
10. C
11. D
12. C
13. A, D
14. B, D
15. $3V/(K+2)$
16. $\frac{1}{3}MRA\omega^2$
17. $\frac{M\omega_0}{M+6m}$
18. 1.256×10^{-23} A m^2
19. $\frac{\mu_0 i}{4}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$
20. positive, p-side, n-side
21. $Mg/(3AK)$
22. 23.6 MeV
23. $v = 2\sqrt{\frac{G}{d}\left(M_1 + M_2\right)}$
24. T
25. F
26. F
27. F
28. (a) $v = \frac{(R+2\lambda x)i}{Bd}$, $F = idB + \frac{2\lambda i^2 m}{B^2 d^2}(R + 2\lambda x)$ (b) $\frac{1}{1+\frac{2m\lambda(R+2\lambda x)i}{B^3 d^3}}$
29. (a) -6 mm, -5 mm
30. (a) $30°$ (b) (108.25 m, 3
31. $v = \sqrt{\frac{GM}{a}}$, $T = 2\pi\sqrt{\frac{a^3}{3Gm}}$
32. (a) $r_n = \frac{n^2 h^2 \epsilon_0}{624\pi m_e e^2}$ (b) $n \approx 25$ (c) 0.548 Å
33. 3.17×10^{-9} C
34. (a) See solution (b) 113 litre, 0.44×10^5 N/m^2, (c) 12463 J
35. (a) 599.33 Hz (b) 29/31 km, 620 Hz
36. 1.5 A, 1.44×10^{-5} J

IIT JEE 1987

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Paper

The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) fill in the blank type (4) true false type (5) matrix matching type and (6) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. During a nuclear fusion reaction,

(A) a heavy nucleus breaks into two fragments by itself.

(B) a light nucleus bombarded by thermal neutrons breaks up.

(C) a heavy nucleus bombarded by thermal neutrons breaks up.

(D) two light nuclei combine to give a heavier nucleus and possibly other products.

Q 2. During negative beta decay,

(A) an atomic electron is ejected.

(B) an electron which is already present within the nucleus is ejected.

(C) a neutron in the nucleus decays emitting an electron.

(D) a part of the binding energy of the nucleus is converted into an electron.

Q 3. A particle executes SHM with a frequency f. The frequency with which its kinetic energy oscillates is
(A) $f/2$ (B) f (C) $2f$ (D) $4f$

Q 4. A charge q is placed at the centre of the line joining two equal charges Q. The system of the three charges will be in equilibrium if q is equal to
(A) $-Q/2$ (B) $-Q/4$ (C) $+Q/4$ (D) $+Q/2$

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 5. Photoelectric effect supports quantum nature of light because

(A) there is a minimum frequency of light below which no photoelectrons are emitted.

(B) the maximum kinetic energy of photoelectrons depends only on the frequency of light and not on intensity.

(C) even when the metal surface is faintly illuminated, the photoelectrons leave the surface immediately.

(D) electric charge of the photoelectrons is quantized.

Q 6. A particle is acted upon by a force of constant magnitude which is always perpendicular to the velocity of the particle. The motion of the particle takes place in plane. It follows that

(A) its velocity is constant.
(B) its acceleration is constant.
(C) its kinetic energy is constant.
(D) it moves in a circular path.

Q 7. A parallel plate capacitor is charged and the charging battery is then disconnected. If the plates of the capacitor are moved farther apart by means of insulating handles,

(A) the charge on the capacitor increases.
(B) the voltage across the plates increases.
(C) the capacitance increases.
(D) the electrostatic energy stored in the capacitor increases.

Q 8. The displacement of particles in a string stretched in the x direction is represented by y. Among the following expressions for y, those describing wave motion is (are)

(A) $\cos kx \sin \omega t$ (B) $k^2x^2 - \omega^2t^2$

(C) $\cos^2(kx + \omega t)$ (D) $\cos\left(k^2x^2 - \omega^2t^2\right)$

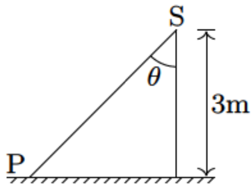
Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

Q 9. A thin lens of refractive index 1.5 has a focal length of 15 cm in air. When the lens is placed in a medium of refractive index 4/3, its focal length will become …… cm.

Q 10. In a sonometer wire, the tension is maintained by suspending a 50.7 kg mass from the free end of the wire. The suspended mass has a volume of $0.0075\ m^3$. The fundamental frequency of vibration of the wire is 260 Hz. If the suspended mass is completely submerged in water, the fundamental frequency will become ...... Hz.

Q 11. Spotlight S rotates in a horizontal plane with constant angular velocity of 0.1 rad/s. The spot of light P moves along the wall at a distance of 3 m. The velocity of the spot P when $\theta = 45°$ (see figure) is ...... m/s.



Q 12. An electric bulb rated for 500 W at 100 V is used in a circuit having a 200 V supply. The resistance R that must be put in series with the bulb, so that the bulb delivers 500 W is $\ldots\ldots$ Ω.

Q 13. During an experiment, an ideal gas is found to obey an additional law $p^2V =$ constant. The gas is initially at a temperature T and volume V. When it expands to a volume $2V$, the temperature becomes ......

Q 14. A wire of length L metre carrying a current i ampere is bent in the form of circle. The magnitude of its magnetic moment is ...... in MKS units.

Q 15. A wire of length L and cross-sectional area A is made of a material of Young's modulus Y. If the wire is stretched by an amount x, the work done is ......

Q 16. A geostationary satellite is orbiting the earth at a height of $6R$ above the surface of the earth where R is the radius of the earth. The time period of another satellite at a height of $2.5R$ from the surface of the earth is ...... h.

Q 17. A particle of mass $4m$ which is at rest explodes into three fragments. Two of the fragments each of mass m are found to move with a speed v each in mutually perpendicular directions. The total energy released in the process of explosion is ......

Matrix or Matching Type

This section contains matrix-matching type questions.

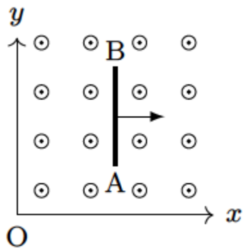
Q 18. Four physical quantities are listed in *Column I*. Their values are listed in *Column II* in a random order. The correct matching of *Column I* and *Column II* is given by,

Column I	Column II
(A) Thermal energy of air molecules at room temp.	(p) 0.02 eV
(B) Binding energy of heavy nuclei per nucleon	(q) 2 eV
(C) X-ray photon energy	(r) 10 keV
(D) Photon energy of visible light	(s) 7 MeV

True False Type

This section contains true false type questions.

Q 19. A conducting rod AB moves parallel to the x-axis in a uniform magnetic field pointing in the z direction. The end A of the rod gets positively charged.



Q 20. At a given temperature, the specific heat of a gas at a constant pressure is always greater than its specific heat at constant volume.

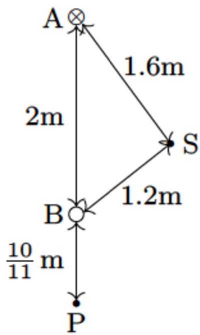
Q 21. In a Young's double slit experiment performed with a source of white light, only black and white fringes are observed.

Q 22. The *rms* speed of oxygen molecules (O_2) at a certain temperature T (degree absolute) is v. If the temperature is doubled and oxygen gas dissociates into atomic oxygen, the *rms* speed remains unchanged.

Descriptive

There are descriptive questions in this section. Solve all of them.

Q 23. Two long straight parallel wires are 2 m apart, perpendicular to the plane of the paper. The wire A carries a current of 9.6 A, directed into the plane of paper. The wire B carries a current such that the magnetic field of induction at the point P, at a distance of $\frac{10}{11}$ m from the wire B, is zero. Find,

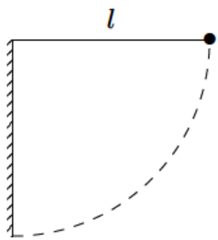


(a) The magnitude and direction of the current in B.
(b) The magnitude of the magnetic field of induction at the point S.
(c) The force per unit length on the wire B.

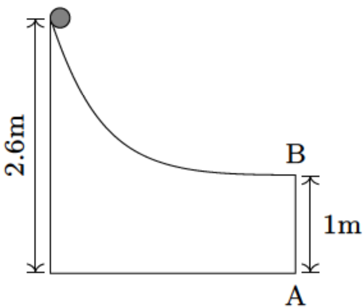
Q 24. A triode has plate characteristics in the form of parallel lines in the region of our interest. At a grid voltage of −1 V the anode current I (in mA) is given in terms of plate voltage V by the algebraic relation: $I = 0.125V - 7.5$. For grid voltage of −3 V, the current at anode voltage of 300 V is 5 mA. Determine the plate resistance (r_p), transconductance (g_m) and the amplification factor (μ) for the triode.

Q 25. A block of mass m rests on a horizontal floor with which it has a coefficient of static friction μ. It is desired to make the body move by applying the minimum possible force F. Find the magnitude of F and the direction in which it has to be applied.

Q 26. A simple pendulum is suspended from a peg on a vertical wall. The pendulum is pulled away from the wall to a horizontal position and released (see figure). The bob hits the wall, the coefficient of restitution being $2/\sqrt{5}$. What is the minimum number of collisions after which the amplitude of oscillations becomes less than $60°$.



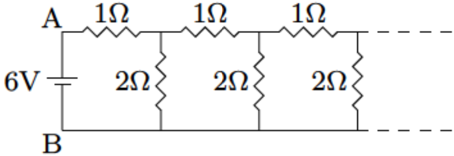
Q 27. A small sphere rolls down without slipping from the top of a track in a vertical plane. The track has an elevated section and a horizontal part. The horizontal part is 1.0 m above the ground level and the top of the track is 2.6 m above the ground. Find the distance on the ground with respect to the point B (which is vertically below the end of the track as shown in the figure) where the sphere lands. During its flight as a projectile, does the sphere continue to rotate about its centre of mass? Explain.



Q 28. Three point charges q, $2q$ and $8q$ are to be placed on a 9 cm long straight line. Find the positions where the charges should be placed such that the potential energy of this system is minimum. In this situation, what is the electric field at the position of the charge q due to the other two charges?

Q 29. An ideal gas has a specific heat at constant pressure $C_p = \frac{5}{2}R$. The gas is kept in a closed vessel of volume $0.0083\ \text{m}^3$, at a temperature of 300 K and pressure of $1.6 \times 10^6\ \text{N/m}^2$. An amount of 2.49×10^4 J of heat energy is supplied to the gas. Calculate the final temperature and pressure of the gas.

Q 30. An infinite ladder network of resistances is constructed with 1 Ω and 2 Ω resistances (see figure). The 6 V battery between A and B has negligible internal resistance.

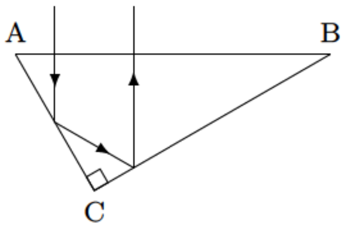


(a) Show that the effective resistance between A and B is 2 Ω.

(b) What is the current that passes through the 2 Ω resistance nearest to the battery?

Q 31. The following equations represent transverse waves: $z_1 = A\cos(kx - \omega t)$, $z_2 = A\cos(kx + \omega t)$, $z_3 = A\cos(ky - \omega t)$. Identify the combination(s) of the waves which will produce (a) standing wave(s), (b) a wave travelling in the direction making an angle of $45°$ with the positive x and positive y-axes. In each case, find the position at which the resultant intensity is always zero.

Q 32. A right angled prism is to be made by selecting a proper material and the angles A and B ($B \leq A$), as shown in the figure. It is desired that a ray of light incident on the face AB emerges parallel to the incident direction after two internal reflections.



(a) What should be the minimum refractive index n for this to be possible?

(b) For $n = 5/3$, is it possible to achieve this with the angle B equal to $30°$?

Answers

1. D
2. C
3. C
4. B
5. A, B, C
6. C, D
7. B, D
8. A, C
9. 60
10. 240
11. 0.6
12. 20
13. $\sqrt{2}T$
14. $iL^2/(4\pi)$
15. $\frac{1}{2}\left(\frac{YA}{L}\right)x^2$
16. 8.48
17. $\frac{3}{2}mv^2$
18. A$\mapsto$p, B$\mapsto$s, C$\mapsto$r, D$\mapsto$q
19. T
20. T
21. F
22. F
23. (a) 3 A $\odot$
(b) 1.3×10^{-6} T
(c) 2.88×10^{-6} N/m
24. 8 kΩ, 1.25×10^{-2} A/V, 100
25. $\frac{\mu mg}{\sqrt{1+\mu^2}}$, $\tan^{-1}\mu$
26. 4
27. 2.13 m, yes
28. (a) $2q$ and $8q$ at ends, q at 3 cm from $2q$ (b) zero
29. 675 K, 3.6×10^6 N/m^2
30. (b) 1.5 A
31. (a) z_1 and z_2; $x = (2n+1)\frac{\pi}{2k}$ where $n = 0, \pm 1, \pm 2, \ldots$ (b) z_1 and z_3; $x - y = (2n+1)\frac{\pi}{k}$ where $n = 0, \pm 1, \pm 2, \ldots$
32. (a) $\sqrt{2}$ (b) No

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Paper

The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) fill in the blanks type (4) true false type and (5) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. Two thin long parallel wires separated by a distance b are carrying a current i ampere each. The magnitude of the force per unit length exerted by one wire on the other is
(A) $\frac{\mu_0 i^2}{b^2}$ (B) $\frac{\mu_0 i^2}{2\pi b}$ (C) $\frac{\mu_0 i}{2\pi b}$ (D) $\frac{\mu_0 i}{2\pi b^2}$

Q 2. A tube, closed at one end and containing air, produces, when excited, the fundamental note of frequency 512 Hz. If the tube is opened at both ends the fundamental frequency that can be excited is (in Hz)
(A) 1024 (B) 512 (C) 256 (D) 128

Q 3. A ball hits the floor and rebounds after an inelastic collision. In this case,

(A) the momentum of the ball just after the collision is the same as that just before the collision.

(B) the mechanical energy of the ball remains the same in the collision.

(C) the total momentum of the ball and the earth is conserved.

(D) the total mechanical energy of the ball and the earth is conserved.

Q 4. A shell is fired from a cannon with a velocity v m/s at an angle θ with the horizontal direction. At the highest point in its path it explodes into two pieces of equal mass. One of the pieces retraces its path to the cannon. The speed (in m/s) of the other piece immediately after the explosion is

(A) $3v\cos\theta$ (B) $2v\cos\theta$ (C) $\frac{3}{2}v\cos\theta$ (D) $\sqrt{\frac{3}{2}}v\cos\theta$

Q 5. Steam at 100 °C is passed into 1.1 kg of water contained in a calorimeter of water equivalent 0.02 kg at 15 °C till the temperature of the calorimeter and its contents rises to 80 °C. The mass of the steam condensed (in kg) is
(A) 0.130 (B) 0.065 (C) 0.260 (D) 0.135

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 6. The mass number of a nucleus is

(A) always less than its atomic number.

(B) always more that its atomic number.

(C) sometimes equal to its atomic number.

(D) sometime more than and sometimes equal to its atomic number.

Q 7. A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen,

(A) half of the image will disappear.
(B) complete image will be formed.
(C) intensity of the image will increase.
(D) intensity of the image will decrease.

Q 8. A simple pendulum of length l and bob mass m is oscillating in a plane about a vertical line between angular limits $-\phi$ and $+\phi$. For an angular displacement θ ($|\theta| < \phi$), the tension in the string and the velocity of the bob are T and v, respectively. The following relations hold good under the above conditions,

(A) $T\cos\theta = mg$.

(B) $T - mg\cos\theta = mv^2/l$.

(C) The magnitude of the tangential acceleration of the bob $|a_T| = g\sin\theta$.

(D) $T = mg\cos\theta$.

Q 9. A reference frame attached to the earth

(A) is an inertial frame by definition.

(B) cannot be inertial frame because the earth is revolving around the sun.

(C) is an inertial frame because Newton's laws are applicable in this frame.

(D) cannot be an inertial frame because the earth is rotating about its own axis.

Q 10. The dimensions of the quantities in one (or more) of the following pairs are the same. Identify the pair(s),

(A) torque and work
(B) angular momentum and work
(C) energy and Young's modulus
(D) light year and wavelength

Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

Q 11. When the number of electrons striking the anode of an X-ray tube is increased the ...... of the emitted X-rays increases while when the speeds of the electrons striking the anode are increased the cut-off wavelength of the emitted X-rays ....

Q 12. Two small balls having equal positive charges Q (coulomb) on each are suspended by two insulating strings of equal length L (metre) from a hook fixed to a stand. The whole set-up is taken in a satellite into space where there is no gravity (state of weightlessness). The angle between the strings is ...... and the tension in each string is ...... newton.

Q 13. Two simple harmonic motions are represented by the equations $y_1 = 10\sin(3\pi t + \pi/4)$ and $y_2 = 5\left(\sin 3\pi t + \sqrt{3}\cos 3\pi t\right)$. Their amplitudes are in the ratio of ......

Q 14. In Young's double slit experiment, the two slits act as coherent sources of equal amplitude A and wavelength λ. In another experiment with the same set-up the two slits are sources of equal amplitude A and wavelength λ, but are incoherent. The ratio of the intensity of light at the mid-point of the screen in the first case to that in the second case is ......

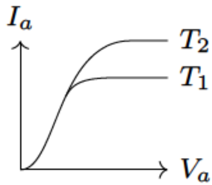
Q 15. Atoms having the same ...... but different ...... are called isotopes.

Q 16. When boron nucleus $\left({}^{10}_{5}\mathrm{B}\right)$ is bombarded by neutrons, α-particles are emitted. The resulting nucleus is of the element ...... and has the mass number ....

True False Type

This section contains true false type questions.

Q 17. For a diode the variation of its anode current I_a with the anode voltage V_a at two different cathode temperatures T_1 and T_2 is shown in the figure. The temperature T_2 is greater than T_1.



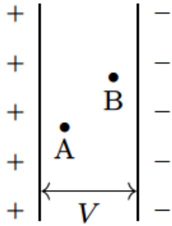
Q 18. In a photoelectric emission process the maximum energy of the photoelectrons increases with increasing intensity of the incident light.

Q 19. A block of ice with a lead shot embedded in it is floating on water contained in a vessel. The temperature of the system is maintained at 0 °C as the ice melts. When the ice melts completely the level of water in the vessel rises.

Q 20. A coil of metal wire is kept stationary in a non-uniform magnetic field. An *emf* is induced in the coil.

Q 21. A thin uniform circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with an angular velocity ω. Another disc of the same dimensions but of mass $M/4$ is placed gently on the first disc coaxially. The angular velocity of the system now is $2\omega/\sqrt{5}$.

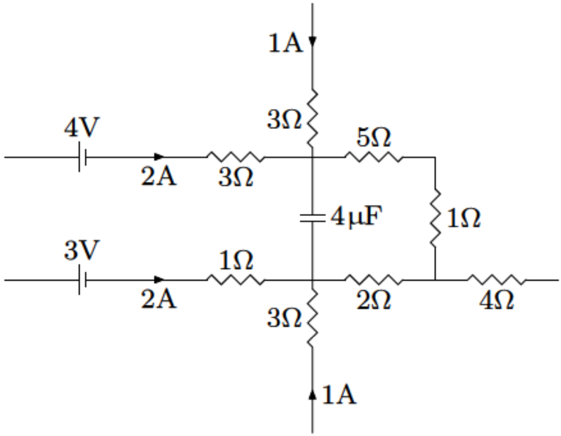
Q 22. Two protons A and B are placed in between the two plates of a parallel plate capacitor charged to a potential difference V as shown in the figure. The forces on the two protons are identical.



Descriptive

There are descriptive questions in this section. Solve all of them.

Q 23. A part of circuit in steady state along with the currents flowing in the branches, the values of resistances etc., is shown in the figure. Calculate the energy stored in the capacitor $C(4\ \mu\text{F})$.



Q 24. Two tuning forks with natural frequencies of 340 Hz each move relative to a stationary observer. One fork moves away from the observer, while the other moves towards him at the same speed. The observer hears beats of frequency 3 Hz. Find the speed of the tuning fork. [Speed of sound = 340 m/s.]

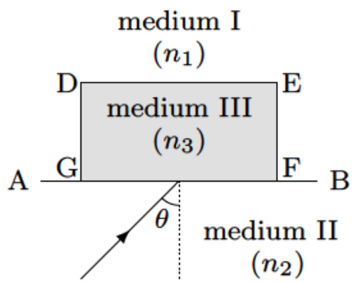
Q 25. A beam of protons with velocity 4×10^5 m/s enters a uniform magnetic field of 0.3 T at an angle of $60°$ to the magnetic field. Find the radius of the helical path taken by the protons beam. Also find the pitch of the helix (which is the distance travelled by a proton in the beam parallel to the magnetic field during one period of rotation).

Q 26. Two satellites S_1 and S_2 revolves around a planet in coplanar circular orbits in the same sense. Their periods of revolution are 1 h and 8 h respectively. The radius of the orbit of S_1 is 10^4 km. When S_2 is closest to S_1, find,

(a) the speed of S_2 relative to S_1.

(b) the angular speed of S_2 as actually observed by an astronaut in S_1.

Q 27. Monochromatic light is incident on a plane interface AB between two media of refractive indices n_1 and n_2 ($n_2 > n_1$) at an angle of incidence θ as shown in the figure. The angle θ is infinitesimally greater than the critical angle for the two media so that total internal reflection takes place. Now if a transparent slab DEFG of uniform thickness and of refractive index n_3 is introduced on the interface (see figure), show that for any value of n_3 all light will ultimately be reflected back again into medium II. Consider separately the cases (a) $n_3 < n_1$ and (b) $n_3 > n_1$.



Q 28. A thin tube of uniform cross-section is sealed at both ends. It lies horizontally, the middle 5 cm containing mercury and the two equal ends containing air at the same pressure p. When the tube is held at an angle 60° with the vertical direction, the length of the air column above and below mercury column are 46 cm and 44.5 cm respectively. Calculate the pressure p in centimetre of mercury. [The temperature of the system is kept at $30\,^\circ$C.]

Q 29. An electric heater is used in a room of total wall area 137 m^2 to maintain a temperature of $+20\,°C$ inside it, when the outside temperature is $-10\,°C$. The walls have three different layers. The innermost layer is of wood of thickness 2.5 cm, the middle layer is of cement of thickness 1.0 cm and the outermost layer is of brick of thickness 25.0 cm. Find the power of the electric heater. Assume that there is no heat loss through the floor and ceiling. The thermal conductivities of wood, cement and brick are 0.125, 1.5 and 1.0 $W\,m^{-1}\,°C^{-1}$, respectively.

Q 30. A body falling freely from a given height H hits an inclined plane in its path at a height h. As a result of this impact the direction of the velocity of the body becomes horizontal. For what value of (h/H) the body will take maximum time to reach the ground?

Q 31. There is a stream of neutrons with kinetic energy of 0.0327 eV. If the half-life of neutrons is 700 s, what fraction of neutrons will decay before they travel a distance of 10 m?

Answers

1. B
2. A
3. C
4. A
5. D
6. C, D
7. B, D
8. B, C
9. B, D
10. A, D
11. intensity, decreases
12. $180°$, $\frac{Q^2}{16\pi\epsilon_0 L^2}$
13. $1:1$
14. 2
15. Atomic Number, Mass Number
16. Li, 7
17. T
18. F
19. F
20. F
21. F
22. T
23. 0.288 mJ
24. 1.5 m/s
25. 1.2×10^{-2} m, 4.37×10
26. (a) $-\pi \times 10^4$ km/h
    (b) 3×10^{-4} rad/s
27. See solution
28. 75.4 cm of Hg
29. 9000 W
30. 1/2
31. 3.96×10^{-6}

IIT JEE 1985

Paper

The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) fill in the blanks type (4) true false type and (5) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. The X-ray beam coming from an X-ray tube will be,

(A) monochromatic.

(B) having all wavelengths smaller than a certain maximum wavelength.

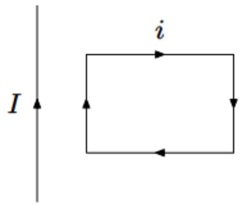
(C) having all wavelengths larger than a certain minimum wavelength.

(D) having all wavelengths lying between a minimum and maximum wavelength.

Q 2. A uniform chain of length L and mass M is lying on a smooth table and one-third of its length is hanging vertically down over the edge of the table. If g is acceleration due to gravity, the work required to pull the hanging part on to the table is
(A) MgL (B) $MgL/3$ (C) $MgL/9$ (D) $MgL/18$

Q 3. 70 cal of heat is required to raise the temperature of 2 mol of an ideal diatomic gas at constant pressure from 30 °C to 35 °C. The amount of heat required to raise the temperature of the same gas through the same range (30 °C to 35 °C) at constant volume is
(A) 30 cal (B) 50 cal (C) 70 cal (D) 90 cal

Q 4. A rectangular loop carrying a current i is situated near a long straight wire such that the wire is parallel to one of the sides of the loop and is in the plane of the loop. If steady current I is established in the wire as shown in the figure, the loop will



(A) rotate about an axis parallel to the wire.
(B) move away from the wire.
(C) move towards the wire.
(D) remain stationary.

Q 5. For a given plate voltage, the plate current in a triode valve is maximum when the potential of

(A) the grid is positive and plate is negative.

(B) the grid is zero and plate is positive.

(C) the grid is negative and plate is positive.

(D) the grid is positive and plate is positive.

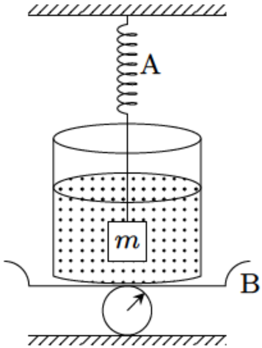
One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 6. A parallel plate air capacitor is connected to a battery. The quantities charge, voltage, electric field and energy associated with this capacitor are given by Q_0, V_0, E_0 and U_0, respectively. A dielectric slab is now introduced to fill the space between the plates with the battery still in connection. The corresponding quantities now given by Q, V, E and U are related to the previous ones as

(A) $Q > Q_0$ (B) $V > V_0$ (C) $E > E_0$ (D) $U > U_0$

Q 7. The spring balance A reads 2 kg with a block m suspended from it. A balance B reads 5 kg when a beaker with liquid is put on the pan of the balance. The two balances are now so arranged that the hanging mass is inside the liquid in the beaker as shown in the figure. In this situation,



(A) the balance A will read more than 2 kg.
(B) the balance B will read more than 5 kg.
(C) the balance A will read less than 2 kg and B will read more than 5 kg.
(D) the balance A and B will read 2 kg and 5 kg, respectively.

Q 8. A proton moving with a constant velocity passes through a region of space without any change in its velocity. If E and B represent the electric and magnetic fields, respectively. Then, the region of space may have

(A) $E = 0, B = 0$ (B) $E = 0, B \neq 0$
(C) $E \neq 0, B = 0$ (D) $E \neq 0, B \neq 0$

Q 9. An air column in a pipe, which is closed at one end, will be in resonance with a vibrating tuning fork of frequency 264 Hz, if the length of the column is [Speed of sound = 330 m/s.]

(A) 31.25 cm (B) 62.50 cm
(C) 93.75 cm (D) 125 cm

Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

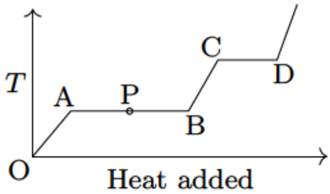
Q 10. A convex lens A of focal length 20 cm and a concave lens B of focal length 5 cm are kept along the same axis with a distance d between them. If a parallel beam of light falling on A leaves B as parallel beam, then d is equal to ...... cm.

Q 11. Planck's constant has dimensions ......

Q 12. In the uranium radioactive series the initial nucleus is $^{238}_{92}U$ and the final nucleus is $^{206}_{82}Pb$. When the uranium nucleus decays to lead, the number of α-particles emitted is ...... and the number of β-particles emitted is ......

Q 13. According to Kepler's second law, the radius vector to a planet from the sun sweeps out equal areas in equal intervals of time. This law is a consequence of the conservation of ......

Q 14. The variation of temperature of a material as heat is given to it at a constant rate is as shown in the figure. The material is in solid state at the point O. The state of the material at the point P is ......



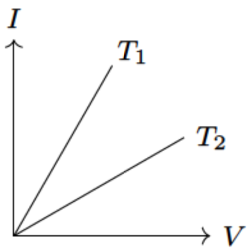
True False Type

This section contains true false type questions.

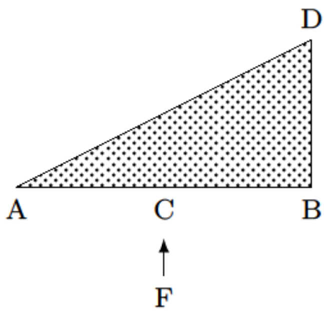
Q 15. A source of sound with frequency 256 Hz is moving with a velocity v towards a wall and an observer is stationary between the source and the wall. When the observer is between the source and the wall he will hear beats.

Q 16. Two identical trains are moving on rails along the equator on the earth in opposite directions with the same speed. They will exert the same pressure on the rails.

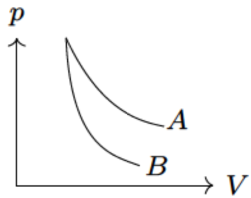
Q 17. The current-voltage graphs for a given metallic wire at two different temperatures T_1 and T_2 are shown in the figure. The temperature T_2 is greater than T_1.



Q 18. A triangular plate of uniform thickness and density is made to rotate about an axis perpendicular to the plane of the paper and (a) passing through A, (b) passing through B, by the application of same force, F, at C (mid-point of AB) as shown in the figure. The angular acceleration in both the cases will be the same.



Q 19. The curves A and B in the figure shows p-V graphs for an isothermal and adiabatic process for an ideal gas. The isothermal process is represented by the curve A.

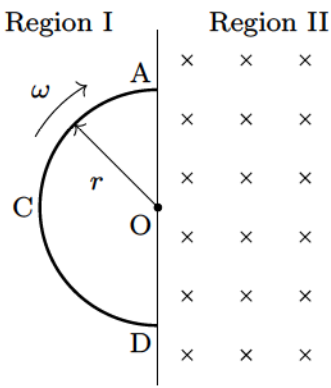


Q 20. An electron and a proton are moving with the same kinetic energy along the same direction. When they pass through a uniform magnetic field perpendicular to the direction of their motion, they describe circular paths of the same radius.

Descriptive

There are descriptive questions in this section. Solve all of them.

Q 21. Space is divided by the line AD into two regions. Region I is field free and the region II has a uniform magnetic field B directed into the plane of the paper. ACD is a semicircular conducting loop of radius r with centre at O, the plane of the loop being in the plane of the paper. The loop is now made to rotate with a constant angular velocity ω about an axis passing through O and perpendicular to the plane of the paper. The effective resistance of the loop is R.



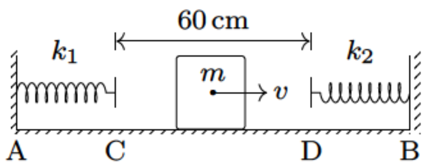
(a) Obtain an expression for the magnitude of the induced current in the loop.
(b) Show the direction of the current when the loop is entering into the region II.
(c) Plot a graph between the induced current and the time of rotation for two periods of rotation.

Q 22. A doubly ionised lithium atom is hydrogen-like with atomic number 3.

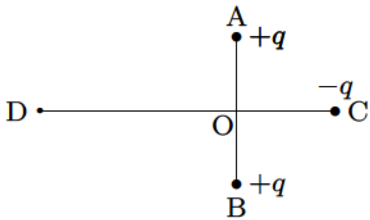
(a) Find the wavelength of the radiation required to excite the electron in Li^{2+} from the first to the third Bohr orbit. [Ionization energy of the hydrogen atom equals 13.6 eV.]

(b) How many spectral lines are observed in the emission spectrum of the above excited system?

Q 23. Two light springs of force constant k_1 and k_2 and a block of mass m are in one line AB on a smooth horizontal table such that one end of each spring is fixed on rigid supports and the other end is free as shown in the figure. The distance CD between the free ends of the springs is 60 cm. If the block moves along AB with a velocity 120 cm/s in between the springs, calculate the period of oscillation of the block. [Take $k_1 = 1.8$ N/m, $k_2 = 3.2$ N/m, $m = 200$ g.]



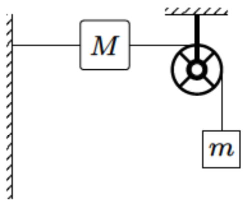
Q 24. Two fixed, equal, positive charges, each of magnitude $q = 5 \times 10^{-5}$ C are located at points A and B separated by a distance 6 m. An equal and opposite charge moves towards them along the line COD, the perpendicular bisector of the line AB. The moving charge, when reaches the point C at a distance of 4 m from O, has a kinetic energy of 4 J. Calculate the distance of the farthest point D which the negative charge will reach before returning towards C.



Q 25. A ball of mass 100 g is projected vertically upwards from the ground with a velocity of 49 m/s. At the same time another identical ball is dropped from a height of 98 m to fall freely along the same path as that followed by the first ball. After some time the two balls collide and stick together and finally fall to the ground. Find the time of flight of the masses.

Q 26. Two glass bulbs of equal volume are connected by a narrow tube and are filled with a gas at 0 °C and pressure 76 cm of mercury. One of the bulbs is then placed in melting ice and the other is placed in a water bath maintained at 62 °C. What is the new value of the pressure inside the bulbs? The volume of the connecting tube is negligible.

Q 27. A string, with one end fixed on a rigid wall, passing over a fixed frictionless pulley at a distance of 2 m from the wall, has a point mass $M = 2$ kg attached to it at a distance of 1 m from the wall. A mass $m = 0.5$ kg attached at the free end is held at rest so that the string is horizontal between the wall and the pulley and vertical beyond the pulley. What will be the speed with which the mass M will hit the wall when the mass m is released? [Take $g = 9.8\ \mathrm{m/s^2}$.]



Q 28. The vibration of a string of length 60 cm fixed at both ends are represented by the equation $y = 4\sin\left(\frac{\pi x}{15}\right)\cos(96\pi t)$, where x and y are in cm and t in second.

(a) What is the maximum displacement of a point at $x = 5$ cm?

(b) Where are the nodes located along the string?

(c) What is the velocity of the particle at $x = 7.5$ cm at $t = 0.25$ s.

(d) Write down the equations of the component waves whose superposition gives above wave.

Q 29. A beam of light consisting of two wavelengths, 6500 Å and 5200 Å is used to obtain interference fringe in a Young's double slit experiment.

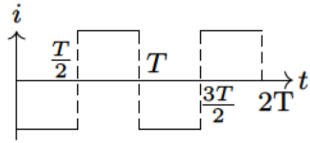
(a) Find the distance of the third bright fringe on the screen from the central maximum of wavelength 6500 Å.

(b) What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide?

The distance between the slits is 2 mm and the distance between the plane of the slits and the screen is 120 cm.

Answers

1. C
2. D
3. B
4. C
5. D
6. A, D
7. B, C
8. A, B, D
9. A,C
10. 15
11. $[ML^2T^{-1}]$
12. eight, six
13. angular momentum
14. partly solid and partly liquid
15. F
16. F
17. T
18. F
19. T
20. F
21. (a) $\frac{1}{2}\frac{Br^2\omega}{R}$ (b) anti-clockwise
(c)



22. (a) 114.15 Å (b) 3
23. 2.832 s
24. From O 8.48 m
25. 6.53 s
26. 83.75 cm of Hg
27. 3.36 m/s
28. (a) $2\sqrt{3}$ cm (b) $x = 0, 15\text{ cm}, 30\text{ cm}\ldots$
(c) zero (d) $y_1 = 2\sin\left(\frac{\pi x}{15} - 96\pi t\right)$ and $y_2 = 2\sin\left(\frac{\pi x}{15} + 96\pi t\right)$
29. (a) 1.17 mm
(b) 1.56 mm

IIT JEE 1984

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Paper

The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) fill in the blanks type (4) true false type and (5) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. Select the correct statement from the following,

(A) a diode can be used as a rectifier.

(B) a triode cannot be used as a rectifier.

(C) the current in a diode is always proportional to the applied voltage.

(D) the linear portion of I-V characteristic of a triode is used for amplification without distortion.

Q 2. A body is moved along a straight line by a machine delivering constant power. The distance moved by the body in time t is proportional to
(A) $t^{1/2}$ (B) $t^{3/4}$ (C) $t^{3/2}$ (D) t^2

Q 3. Two equal negative charges $-q$ are fixed at points $(0, -a)$ and $(0, a)$ on y-axis. A positive charge Q is released from rest at the point $(2a, 0)$ on the x-axis. The charge Q will

(A) execute SHM about the origin.
(B) move to the origin and remain at rest.
(C) move to infinity.
(D) execute oscillatory but not SHM.

Q 4. A transverse wave is described by the equation $y = y_0 \sin(2\pi(ft - x/\lambda))$. The maximum particle velocity is equal to four times the wave velocity if

(A) $\lambda = \pi y_0/4$ (B) $\lambda = \pi y_0/2$

(C) $\lambda = \pi y_0$ (D) $\lambda = 2\pi y_0$

Q 5. At room temperature, the *rms* speed of the molecules of a certain diatomic gas is found to be 1930 m/s. The gas is

(A) H_2 (B) F_2 (C) O_2 (D) Cl_2

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 6. L, C and R represents the physical quantities inductance, capacitance and resistance, respectively. The combination(s) which have the dimensions of frequency is (are)

(A) $1/(RC)$ (B) R/L (C) $1/\sqrt{LC}$ (D) C/L

Q 7. White light is used to illuminate the two slits in a Young's double slit experiment. The separation between the slits is b and the screen is at a distance $d\,(\gg b)$ from the slits. At a point on the screen directly in front of one of the slits, certain wavelengths are missing. Some of these missing wavelengths are

(A) $\lambda = \frac{b^2}{d}$ (B) $\lambda = \frac{2b^2}{d}$ (C) $\lambda = \frac{b^2}{3d}$ (D) $\lambda = \frac{2b^2}{3d}$

Q 8. From the following equations pick out the possible nuclear fusion reactions.

(A) ${}_6C^{13} + {}_1H^1 \rightarrow {}_6C^{14} + 4.3$ MeV

(B) ${}_6C^{12} + {}_1H^1 \rightarrow {}_7N^{13} + 2$ MeV

(C) ${}_7N^{14} + {}_1H^1 \rightarrow {}_8O^{15} + 7.3$ MeV

(D) ${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{54}Xe^{140} + {}_{36}Sr^{94} + 2\,{}_0n^1 + \gamma +$ 200 MeV

Q 9. In the Bohr's model of the hydrogen atom,

(A) the radius of the n^{th} orbit is proportional to n^2.

(B) the total energy of the electron in the n^{th} orbit is inversely proportional to n.

(C) the angular momentum of the electron in an orbit is an integral multiple of h/π.

(D) the magnitude of the potential energy of the electron in any orbit is greater than its kinetic energy.

Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

Q 10. One mole of a monatomic ideal gas is mixed with one mole of a diatomic ideal gas. The molar specific heat of the mixture at constant volume is ......

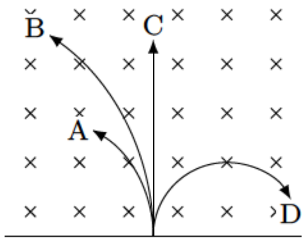
Q 11. Four persons K, L, M, N are initially at the four corners of a square of side d. Each person now moves with a uniform speed v in such a way that K always moves directly towards L, L directly towards M, M directly towards N and N directly towards K. The four persons will meet at a time ......

Q 12. A block of mass 1 kg lies on a horizontal surface in a truck. The coefficient of static friction between the block and the surface is 0.6. If the acceleration of the truck is $5\,\mathrm{m/s^2}$, the frictional force acting on the block is . . . . . . N.

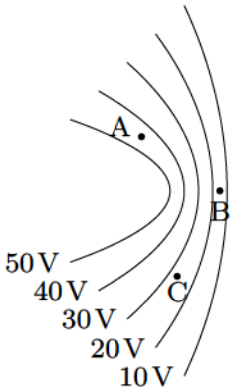
Q 13. A uniform cube of side a and mass m rests on a rough horizontal table. A horizontal force F is applied normal to one of the faces at a point that is directly above the centre of the face, at a height $3a/4$ above the base. The minimum value of F for which the cube begins to tip about the edge is . . . . . . (Assume that the cube does not slide.)

Q 14. The numerical value of the angular velocity of rotation of the earth should be ...... rad/s in order to make the effective acceleration due to gravity at the equator equal to zero.

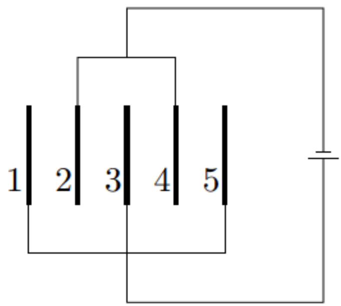
Q 15. A neutron, a proton, an electron and an alpha particle enter a region of constant magnetic field with equal velocities. The magnetic field is along the inward normal to the plane of the paper. The tracks of the particles are labeled in the figure. The electron follows track ...... and the alpha particle follows track ......



Q 16. Figure shows lines of constant potential in a region in which an electric field is present. The values of the potential of each line is also shown. Of the points A, B and C, the magnitude of the electric field is the greatest at the point ......



Q 17. Five identical capacitor plates, each of area A, are arranged such that adjacent plates are at a distance d apart, the plates are connected to a source of *emf* V as shown in the figure. The charge on plate 1 is ...... and on plate 4 is ......



Q 18. The maximum kinetic energy of electron emitted in the photoelectric effect is linearly dependent on the ...... of the incident radiation.

Q 19. Sound waves of frequency 660 Hz fall normally on a perfectly reflecting wall. The shortest distance from the wall at which the air particles have maximum amplitude of vibration is ...... m. [Speed of sound = 330 m/s.]

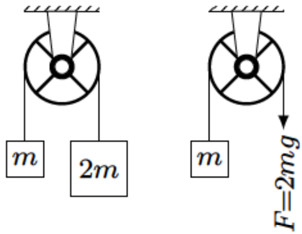
True False Type

This section contains true false type questions.

Q 20. Two slits in a Young's double slit experiment are illuminated by two different sodium lamps emitting light of the same wavelength. No interference pattern will be observed on the screen.

Q 21. A projectile fired from the ground follows a parabolic path. The speed of the projectile is minimum at the top of its path.

Q 22. The pulley arrangements of figure (a) and (b) are identical. The mass of the rope is negligible. In figure (a) the mass m is lifted up by attaching a mass $2m$ to the other end of the rope. In figure (b), m is lifted up by pulling the other end of the rope with a constant downward force $F = 2mg$. The acceleration of m is the same in both cases.



(a) (b)

Q 23. A plane wave of sound travelling in air is incident upon a plane water surface. The angle of incidence is 60°. Assuming Snell's law to be valid for sound waves, it follows that the sound wave will be refracted into water away from the normal.

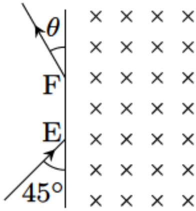
Q 24. A simple pendulum with a bob of mass m swings with an angular amplitude of $40°$. When its angular displacement is $20°$, the tension in the string is greater than $mg\cos 20°$.

Q 25. It is possible to put an artificial satellite into orbit in such a way that it will always remain directly over New Delhi.

Descriptive

There are descriptive questions in this section. Solve all of them.

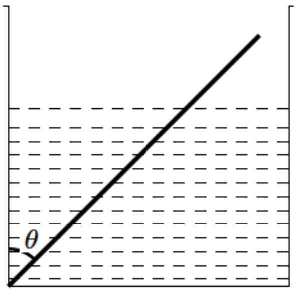
Q 26. A particle of mass $m = 1.6 \times 10^{-27}$ kg and charge $q = 1.6 \times 10^{-19}$ C enters a region of uniform magnetic field of strength 1 T along the direction shown in figure. The speed of the particle is 10^7 m/s.



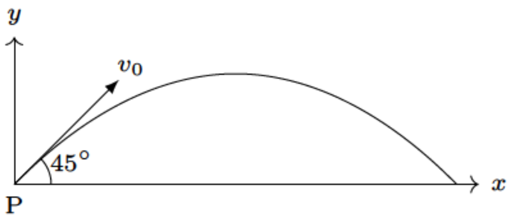
(a) The magnetic field is directed along the inward normal to the plane of paper. The particle leaves the region of the field at the point F. Find the distance EF and the angle θ.

(b) If the direction of the field is along the outward normal to the plane of paper, find the time spent by the particle in the region of the magnetic field after entering it at E.

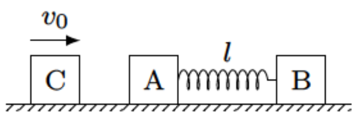
Q 27. A wooden plank of length 1 m and uniform cross-section is hinged at one end to the bottom of a tank as shown in the figure. The tank is filled with water upto a height 0.5 m. The specific gravity of the plank is 0.5. Find the angle θ that the plank makes with the vertical in the equilibrium position. [Exclude the case $\theta = 0°$.]



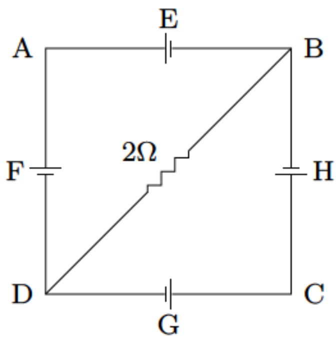
Q 28. A particle is projected at time $t = 0$ from a point P on the ground with a speed v_0, at an angle of $45°$ to the horizontal. Find the magnitude and direction of the angular momentum of the particle about P at time $t = v_0/g$.



Q 29. Two bodies A and B of masses m and $2m$ respectively are placed on a smooth floor. They are connected by a spring. A third body C of mass m moves with a velocity v_0 along the line joining A and B and collides elastically with A as shown in the figure. At a certain instant of time t_0 after collision, it is found that the instantaneous velocities of A and B are the same. Further, at this instant the compression of the spring is found to be x_0. Determine (a) the common velocity of A and B at time t_0, and (b) the spring constant.



Q 30. In the circuit shown in figure E, F, G, H are cells of *emf* 2, 1, 3 and 1 V, respectively and their internal resistances are 2, 1, 3 and 1 Ω, respectively. Calculate,



(a) the potential difference between B and D.
(b) the potential difference across the terminals of each of the cells G and H.

Q 31. A steel wire of length 1 m, mass 0.1 kg and uniform cross-sectional area $10^{-6}\,\mathrm{m}^2$ is rigidly fixed at both ends. The temperature of the wire is lowered by 20 °C. If transverse waves are set-up by plucking the string in the middle, calculate the frequency of the fundamental mode of vibration. [Given $Y_{\text{steel}} = 2 \times 10^{11}\ \mathrm{N/m^2}$, $\alpha_{\text{steel}} = 1.21 \times 10^{-5}\ /°\mathrm{C}$.]

Q 32. A uniform rope of length 12 m and mass 6 kg hangs vertically from a rigid support. A block of mass 2 kg is attached to the free end of the rope. A transverse pulse of wavelength 0.06 m is produced at the lower end of the rope. What is the wavelength of the pulse when it reaches the top of the rope?

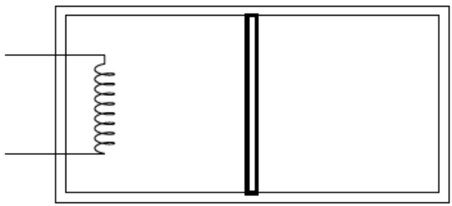
Q 33. The ionization energy of a hydrogen like Bohr atom is 4 Rydberg.

(a) What is the wavelength of the radiation emitted when the electron jumps from the first excited state to the ground state?

(b) What is the radius of the first orbit for this atom?

Q 34. A plano-convex lens has a thickness of 4 cm. When placed on a horizontal table, with the curved surface in contact with it, the apparent depth of the bottom most point of the lens is found to be 3 cm. If the lens is inverted such that the plane face is in contact with the table, the apparent depth of the centre of the plane face of the lens is found to be 25/8 cm. Find the focal length of the lens. [Assume thickness to be negligible while finding its focal length.]

Q 35. The rectangular box shown in the figure has a partition which can slide without friction along the length of the box. Initially each of the two chambers of the box has one mole of a monatomic ideal gas ($\gamma = 5/3$) at a pressure p_0, volume V_0 and temperature T_0. The chamber on the left is slowly heated by an electric heater. The walls of the box and the partition are thermally insulated. Heat loss through the lead wires of the heaters is negligible. The gas in the left chamber expands pushing the partition until the final pressure in both chambers become $243p_0/32$. Determine (a) the final temperature of the gas in each chamber, and (b) the work done by the gas in the right chamber.



Answers

1. A
2. C
3. D
4. B
5. A
6. A, B, C
7. A, C
8. B, C
9. A, D
10. $2R$
11. d/v
12. 5
13. $\frac{2}{3}mg$
14. 1.24×10^{-3}
15. D, B
16. B
17. $\frac{\epsilon_0 AV}{d}, -\frac{2\epsilon_0 AV}{d}$
18. Frequency
19. 0.125
20. T
21. T
22. F
23. T
24. T
25. F
26. (a) 0.14 m, 45° (b) 4.71×10^{-8} s
27. 45°
28. $-\frac{mv_0^3}{2\sqrt{2}g}\hat{k}$
29. (a) $\frac{v_0}{3}$ (b) $\frac{2mv_0^2}{3x_0^2}$
30. (a) $\frac{2}{13}$ V (b) $\frac{21}{13}$ V, $\frac{19}{13}$ V
31. 11 Hz
32. 0.12 m
33. (a) 30.4 nm (b) 0.2645 Å
34. 75 cm
35. (a) $T_1 = 12.94T_0$, $T_2 = 2.25T_0$ (b) $-1.875RT_0$

IIT JEE 1983

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Paper

The paper contains questions of (1) single option correct type (2) fill in the blanks type (3) true false type (4) descriptive type and (5) matrix matching type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. If elements with principal quantum number $n > 4$ were not allowed in nature, the number of possible elements would be
(A) 60 (B) 32 (C) 4 (D) 64

Q 2. A river is flowing from west to east at a speed of 5 m/min. A man on the south bank of the river, capable of swimming at 10 m/min in still water, wants to swim across the river in the shortest time. He should swim in a direction

(A) due north (B) 30° east of north

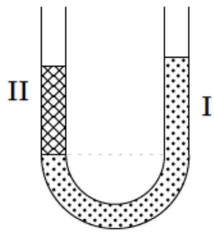
(C) 30° west of north (D) 60° east of north

Q 3. A thin circular ring of mass M and radius r is rotating about its axis with a constant angular velocity ω. Two objects, each of mass m, are attached gently to the opposite ends of a diameter of the ring. The wheel now rotates with an angular velocity

(A) $\frac{\omega M}{M+m}$ (B) $\frac{\omega(M-2m)}{M+2m}$ (C) $\frac{\omega M}{M+2m}$ (D) $\frac{\omega(M+2m)}{M}$

Q 4. If g is the acceleration due to gravity on the earth's surface, the gain in the potential energy of an object of mass m raised from the surface of the earth to a height equal to the radius R of the earth, is
(A) $\frac{1}{2}mgR$ (B) $2mgR$ (C) mgR (D) $\frac{1}{4}mgR$

Q 5. A U-tube of uniform cross-section is partially filled with a liquid I. Another liquid II which does not mix with liquid I is poured into one side. It is found that the liquid levels of the two sides of the tube are same, while the level of liquid I has risen by 2 cm. If the specific gravity of the liquid I is 1.1, the specific gravity of liquid II must be



(A) 1.12 (B) 1.1 (C) 1.05 (D) 1.0

Q 6. A conducting circular loop of radius r carries a constant current i. It is placed in a uniform magnetic field $\vec{B}_0$ such that $\vec{B}_0$ is perpendicular to the plane of the loop. The magnetic force acting on the loop is
(A) $ir\vec{B}_0$ (B) $2\pi ir\vec{B}_0$ (C) zero (D) $\pi ir\vec{B}_0$

Q 7. A hollow metal sphere of radius 5 cm is charged such that the potential on its surface is 10 V. The potential at the centre of the sphere is

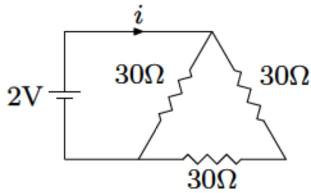
(A) zero.

(B) 10 V.

(C) same as at a point 5 cm away from the surface.

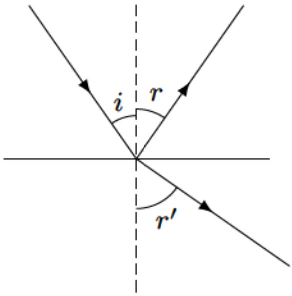
(D) same as at a point 25 cm away from the surface.

Q 8. The current i in the circuit (see figure) is



(A) 1/45 A (B) 1/15 A (C) 1/10 A (D) 1/5 A

Q 9. A ray of light from denser medium strikes a rarer medium at an angle of incidence i (see figure). The reflected and refracted rays make an angle of $90°$ with each other. The angles of reflection and refraction are r and r'. The critical angle is



(A) $\sin^{-1}(\tan r)$ (B) $\sin^{-1}(\cot i)$
(C) $\sin^{-1}(\tan r')$ (D) $\tan^{-1}(\sin i)$

Q 10. Beta rays emitted by a radioactive material are

(A) electromagnetic radiation.
(B) the electron orbiting around the nucleus.
(C) charged particles emitted by the nucleus.
(D) neutral particle.

Q 11. Consider the spectral line resulting from the transition $n = 2$ to $n = 1$ in the atoms and ions given below. The shortest wavelength is produced by

(A) hydrogen atom.

(B) deuterium atom.

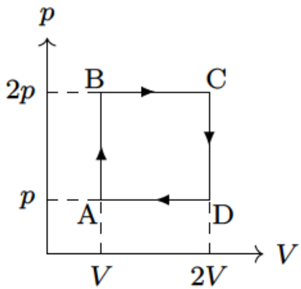
(C) singly ionized helium.

(D) double ionized lithium.

Q 12. The equation $4\,{}^{1}_{1}\mathrm{H} \rightarrow {}^{4}_{2}\mathrm{He}^{2+} + 2e^{-} + 26\,\mathrm{MeV}$, represents

(A) β-decay (B) γ-decay (C) fusion (D) fission

Q 13. An ideal monatomic gas is taken round the cycle ABCDA as shown in the p-V diagram (see figure). The work done during the cycle is



(A) pV (B) $2pV$ (C) $\frac{1}{2}pV$ (D) zero

Fill in the Blank Type

There are fill in the blank type questions in this section. Each question is of two marks.

Q 14. A light wave of frequency 5×10^{14} Hz enters a medium of refractive index 1.5. In the medium the velocity of light wave is ...... and its wavelength is ......

Q 15. A particle moves in a circle of radius R. In half the period of revolution its displacement is ...... and distance covered is ......

Q 16. A travelling wave has the frequency ν and the particle displacement amplitude A. For the wave the particle velocity amplitude is ...... and the particle acceleration amplitude is ......

Q 17. To produce characteristic X-rays using a tungsten target in an X-ray generator, the accelerating voltage should be greater than ......V and the energy of the characteristic radiation is ......eV. [The binding energy of the innermost electron in tungsten is 40 keV.]

Q 18. The radioactive decay rate of a radioactive element is found to be 10^3 disintegration per second at a certain time. If the half-life of the element is one second, the decay rate after one second is ...... and after three seconds is ......

Matrix or Matching Type

This section contains matrix-matching type questions.

Q 19. Match the physical quantities given in *Column I* with dimensions expresses in terms of mass (M), length (L), time (T), and charge (Q) given in *Column II*.

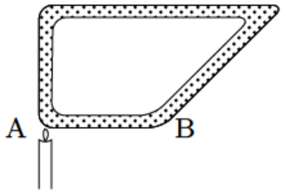
Column I	Column II
(A) Angular Momentum	(p) $[M\ L^2\ T^{-2}]$
(B) Latent Heat	(q) $[M\ L^2\ Q^{-2}]$
(C) Torque	(r) $[M\ L^2\ T^{-1}]$
(D) Capacitance	(s) $[M\ L^3\ T^{-1}\ Q^{-2}]$
(E) Inductance	(t) $[M^{-1}\ L^{-2}\ T^2\ Q^2]$
(F) Resistivity	(u) $[L^2\ T^{-2}]$

True False Type

This section contains true false type questions.

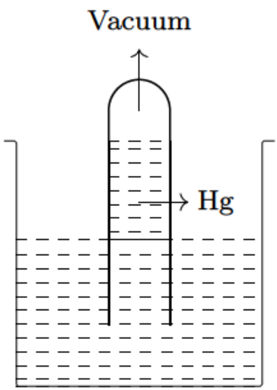
Q 20. There is no change in the energy of a charged particle moving in magnetic field although a magnetic force is acting on it.

Q 21. Water in a closed tube (see figure) is heated with one arm vertically placed above a lamp. Water will begin to circulate along the tube in counter-clockwise direction.



Q 22. Two balls of different masses are thrown vertically upwards with the same speed. They pass through the point of projection in their downward motion with the same speed. [Neglect air resistance.]

Q 23. A barometer made of a very narrow tube (see figure) is placed at normal temperature and pressure. The coefficient of volume expansion of mercury is $0.00018\,/°C$ and that of the tube is negligible. The temperature of mercury in the barometer is now raised by $1\,°C$ but the temperature of the atmosphere does not change. Then, the mercury height in the tube remains unchanged.



Q 24. A charged particle enters a region of uniform magnetic field at an angle of $85°$ to the magnetic lines of force. The path of the particle is a circle.

Q 25. A small metal ball is suspended in a uniform electric field with the help of an insulated thread. If high energy X-ray beam falls on the ball, the ball will be deflected in the direction of the field.

Q 26. Two identical metallic spheres of exactly equal masses are taken. One is given a positive charge Q coulomb and the other an equal negative charge. Their masses after charging are different.

Q 27. A convex lens of focal length 1 m and concave lens of focal length 0.25 m are kept 0.75 m apart. A parallel beam of light first passes through the convex lens, then through the concave lens and comes to a focus 0.5 m away from the concave lens.

Q 28. A beam of white light passing through a hollow prism gives no spectrum.

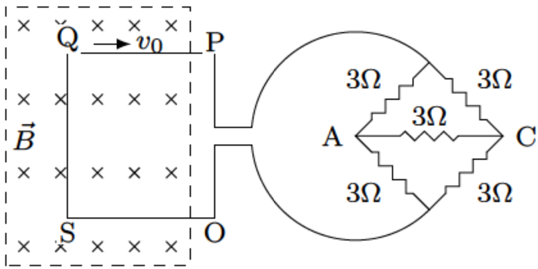
Q 29. The ratio of the velocity of sound in hydrogen gas ($\gamma = 7/5$) to that in helium gas ($\gamma = 5/3$) at the same temperature is $\sqrt{21/5}$.

Descriptive

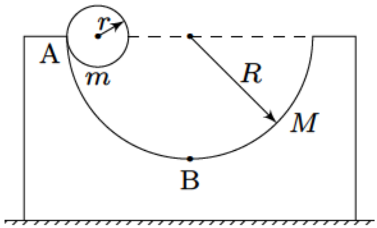
There are descriptive questions in this section. Solve all of them.

Q 30. A sonometer wire under tension of 64 N vibrating in its fundamental mode is in resonance with a vibrating tuning fork. The vibrating portion of the sonometer wire has a length of 10 cm and mass of 1 g. The vibrating tuning fork is now moved away from the vibrating wire with a constant speed and an observer standing near the sonometer hears one beat per second. Calculate the speed with which the tuning fork is moved, if the speed of sound in air is 300 m/s.

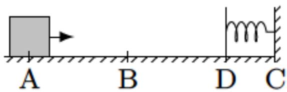
Q 31. A square metal wire loop of side 10 cm and resistance 1 Ω is moved with a constant velocity v_0 in a uniform magnetic field of induction $B = 2\,\mathrm{Wb/m^2}$ as shown in the figure. The magnetic field lines are perpendicular to the plane of the loop (directed into the paper). The loop is connected to a network of resistors each of value 3 Ω. What should be the speed of the loop so as to have a steady current of 1 mA in the loop? Give the direction of current in the loop.



Q 32. A block of mass M with semicircular track of radius R rests on a horizontal frictionless surface. A uniform cylinder of radius r and mass m is released from rest at the top point A (see figure). The cylinder slips on the semicircular frictionless track. How far has the block moved when the cylinder reaches the bottom (point B) of the track? How fast is the block moving when the cylinder reaches the bottom of the track?



Q 33. A 0.5 kg block slides from the point A (see figure) on a horizontal track with an initial speed of 3 m/s towards a weightless horizontal spring of length 1 m and force constant 2 N/m. The part AB of the track is frictionless and the part BC has the coefficients of static and kinetic friction as 0.22 and 0.2 respectively. If the distances AB and BD are 2 m and 2.14 m respectively, find the total distance through which the block moves before it comes to rest completely. [Take $g = 10 \text{ m/s}^2$.]

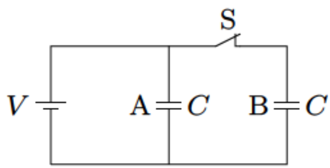


Q 34. In Young's double slit experiment using monochromatic light the fringe pattern shifts by a certain distance on the screen when a mica sheet of refractive index 1.6 and thickness 1.964 μm is introduced in the path of one of the interfering waves. The mica sheet is then removed and the distance between the slits and the screen is doubled. It is found that the distance between successive maxima (or minima) now is the same as the observed fringe shift upon the introduction of the mica sheet. Calculate the wavelength of the monochromatic light used in experiment.

Q 35. Ultraviolet light of wavelength 800 Å and 700 Å when allowed to fall on hydrogen atoms in their ground state is found to liberate electrons with kinetic energy 1.8 eV and 4.0 eV respectively. Find the value of Planck's constant?

Q 36. One gram mole of oxygen at 27 °C and one atmospheric pressure is enclosed in a vessel. (a) Assuming the molecules to be moving with v_{rms}, find the number of collisions per second which the molecules makes with one square metre area of vessel. (b) The vessel is next thermally insulated and moved with constant speed v_0. It is then suddenly stopped. The process results in a rise of the temperature of the gas by 1 °C. Calculate the speed v_0.

Q 37. The figure shows two identical parallel plate capacitors connected to a battery with the switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant (or relative permittivity) 3. Find the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of the dielectric.



Answers

1. A
2. A
3. C
4. A
5. B
6. C
7. B
8. C
9. A
10. C
11. D
12. C
13. A
14. 2×10^8 m/s, 4×10^{-7} m
15. $2R, \pi R$
16. $2\pi\nu A$, $4\pi^2\nu^2 A$
17. 40×10^3, 30×10^3
18. 500 dps, 125 dps
19. A $\mapsto$ r, B $\mapsto$ u, C $\mapsto$ p, D $\mapsto$ t, E $\mapsto$ q, F $\mapsto$ s
20. T
21. F
22. T
23. F
24. F
25. T
26. T
27. F
28. T
29. F
30. 0.75 m/s
31. 0.02 m/s, induced current is clockwise
32. $\frac{m(R-r)}{M+m}$, $m\sqrt{\frac{2g(R-r)}{M(M+m)}}$
33. 4.24 m
34. 5892 Å
35. 6.6×10^{-34} J s
36. (a) 1.96×10^{27} /s (b) 36 m/s
37. 3/5

IIT JEE 1982

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Paper

The paper contains questions of (1) single option correct type (2) one or more option(s) correct type (3) true false type and (4) descriptive type.

One Option Correct

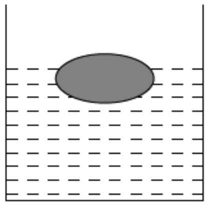
Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. A convex lens of focal length 40 cm is in contact with a concave lens of focal length 25 cm. The power of the combination is
(A) $-1.5D$ (B) $-6.5D$ (C) $+6.5D$ (D) $+6.67D$

Q 2. A magnetic needle is kept in a non-uniform magnetic field. It experiences

(A) a force and a torque
(B) a force but not a torque
(C) a torque but not a force
(D) neither a force nor a torque

Q 3. A body floats in a liquid contained in a beaker. The whole system as shown in the figure, falls freely under gravity. The upthrust on the body is



(A) zero.
(B) equal to the weight of the liquid displaced.
(C) equal to the weight of the body in air.
(D) equal to the weight of the immersed portion of the body.

Q 4. Two particles A and B initially at rest, move towards each other by mutual force of attraction. At the instant when the speed of A is v and the speed of B is $2v$, the speed of the centre of mass of the system is
(A) $3v$ (B) v (C) $1.5v$ (D) zero

Q 5. In the arrangement shown in the figure the end P and Q of an unstretchable string move downwards with uniform speed U. Pulleys A and B are fixed. Mass M moves upwards with a speed

(A) $2U\cos\theta$ (B) $U/\cos\theta$ (C) $2U/\cos\theta$ (D) $U\cos\theta$

Q 6. A particle is moving eastwards with a velocity of 5 m/s. In 10 s the velocity changes to 5 m/s northwards. The average acceleration in this time is

(A) zero.

(B) $\frac{1}{\sqrt{2}}$ m/s^2 towards north-east.

(C) $\frac{1}{\sqrt{2}}$ m/s^2 towards north-west.

(D) 1/2 m/s^2 towards north.

Q 7. The shortest wavelength of X-ray emitted from an X-ray tube depends on

(A) the current in the tube.

(B) the voltage applied to the tube.

(C) the nature of the gas in tube.

(D) the atomic number of the target material.

One or More Option(s) Correct

Each question in this section has four options (A), (B), (C) and (D). One or more than one of these four option(s) is(are) correct. Each question is of two marks.

Q 8. In the Young's double slit experiment, the interference pattern is found to have an intensity ratio between the bright and dark fringes as 9. This implies that

(A) the intensities at the screen due to the two slits are 5 units and 4 units respectively.

(B) the intensities at the screen due to the two slits are 4 units and 1 units respectively.

(C) the amplitude ratio is 3.

(D) the amplitude ratio is 2.

Q 9. A wave equation which gives the displacement along the y direction is given by: $y = 10^{-4} \sin(60t + 2x)$ where x and y are in metre and t is in second. This represents a wave

(A) travelling with a velocity of 30 m/s in the negative x direction.

(B) of wavelength π m.

(C) of frequency $30/\pi$ Hz.

(D) of amplitude 10^{-4} m .

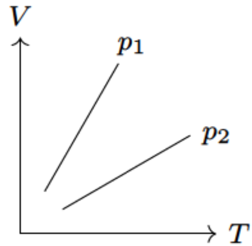
Q 10. The threshold wavelength for photoelectric emission from a material is 5200 Å. Photoelectrons will be emitted when this material is illuminated with monochromatic radiations from a

(A) 50 W infrared lamp
(B) 1 W infrared lamp
(C) 50 W ultraviolet lamp
(D) 1 W ultraviolet lamp

True False Type

This section contains true false type questions.

Q 11. The volume V *versus* temperature T graphs for a certain amount of a perfect gas at two pressure p_1 and p_2 are as shown in the figure. It follows from the graphs that p_1 is greater than p_2.



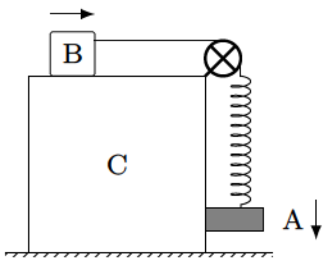
Q 12. Two different gases at the same temperature have equal *rms* velocities.

Q 13. Electrons in a conductor have no motion in the absence of a potential difference across it.

Descriptive

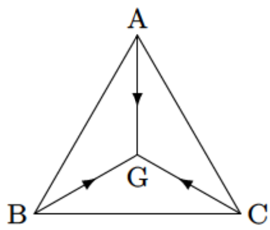
There are descriptive questions in this section. Solve all of them.

Q 14. Two blocks A and B are connected to each other by a string and a spring; the string passes over a frictionless pulley as shown in the figure. Block B slides over the horizontal top surface of a stationary block C and the block A slides along the vertical side of C, both with the same uniform speed. The coefficient of friction between the surfaces of blocks is 0.2. Force constant of the spring is 1960 N/m. If mass of block A is 2 kg, calculate the mass of the block B and the energy stored in the spring.

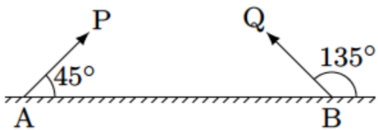


Q 15. Write the dimensions of (a) Magnetic flux and (b) Rigidity modulus, in terms of mass (M), time (T), length (L) and charge (Q).

Q 16. Three particles A, B and C of equal mass move with equal speed v along the medians of an equilateral triangle as shown in the figure. They collide at the centroid G of the triangle. After the collision, A comes to rest, B retraces its path with the speed v. What is the velocity of C?

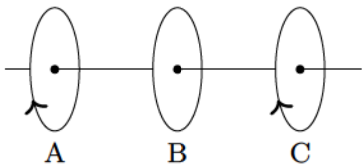


Q 17. Particles P and Q of mass 20 g and 40 g respectively are simultaneously projected from points A and B on the ground. The initial velocities of P and Q makes 45° and 135° angles respectively with the horizontal AB as shown in the figure. Each particle has an initial speed of 49 m/s. The separation AB is 245 m. Both particles travel in the same vertical plane and undergo a collision. After the collision, P retraces its path. Determine the position of Q where it hits the ground. How much time after the collision does the particle Q take to reach the ground? [Take $g = 9.8\ \mathrm{m/s^2}$.]



Q 18. A thin fixed ring of radius 1 m has a positive charge 1×10^{-5} C uniformly distributed over it. A particle of mass 0.9 g and having a negative charge of 1×10^{-6} C is placed on the axis at a distance of 1 cm from the centre of the ring. Show that the motion of the negatively charged particle is approximately simple harmonic. Calculate time period of oscillations.

Q 19. Three identical closed coils A, B and C are placed with their planes parallel to one another. Coils A and C carry equal currents as shown in the figure. Coils B and C are fixed in position and coil A is moved towards B with uniform motion. Is there any induced current in B? If no, give reasons. If yes, mark the direction of the induced current in the diagram.

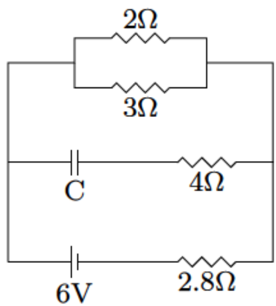


Q 20. A particle of mass 1×10^{-26} kg and charge $+1.6 \times 10^{-19}$ C traveling with a velocity 1.28×10^{6} m/s in the $+x$ direction enters a region in which a uniform electric field E and a uniform magnetic field of induction B are present such that $E_x = E_y = 0$, $E_z = -102.4$ kV/m and $B_x = B_z = 0$, $B_y = 8 \times 10^{-2}$ T. The particle enters this region at the origin at time $t = 0$. Determine the location (x, y, z) of the particle at $t = 5 \times 10^{-6}$ s. If the electric field is switched off at this instant (with the magnetic field still present), what will be the position of the particle at $t = 7.45 \times 10^{-6}$ s?

Q 21. Two resistors, 400 Ω and 800 Ω are connected in series with a 6 V battery. It is desired to measure the current in the circuit. An ammeter of 10 Ω resistance is used for this purpose. What will be the reading in the ammeter? Similarly, if a voltmeter of 1000 Ω resistance is used to measure the potential difference across the 400 Ω resistor, what will be the reading in the voltmeter?

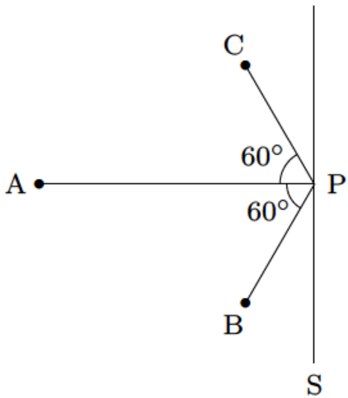
Q 22. A steady current passes through a cylindrical conductor. Is there an electric field inside the conductor?

Q 23. Calculate the steady state current in the $2\ \Omega$ resistor shown in the circuit (see figure). The internal resistance of the battery is negligible and the capacitance of the condenser is $0.2\ \mu F$.



Q 24. A string 25 cm long and having a mass of 2.5 g is under tension. A pipe closed at one end is 40 cm long. When the string is set vibrating in its first overtone and the air in the pipe in its fundamental frequency, 8 beats/s are heard. It is observed that decreasing the tension in the string decreases the beat frequency. If the speed of sound in air is 320 m/s find the tension in the string.

Q 25. Screen S is illuminated by two point sources A and B. Another source C sends a parallel beam of light towards point P on the screen (see figure). Line AP is normal to the screen and the lines AP, BP and CP are in one plane. The distances AP, BP and CP are 3 m, 1.5 m and 1.5 m. The radiant powers of sources A and B are 90 W and 180 W respectively. The beam from C is of intensity 20 W/m^2. Calculate intensity at P on the screen.



Q 26. A solid sphere of copper of radius R and a hollow sphere of the same material of inner radius r and outer radius R are heated to the same temperature and allowed to cool in the same environment. Which of them starts cooling faster?

Q 27. Calculate the work done when one mole of a perfect gas is compressed adiabatically. The initial pressure and volume of the gas are 10^5 N/m^2 and 6 litre respectively. The final volume of the gas is 2 litre. Molar specific heat of the gas at constant volume is $3R/2$.

Q 28. A uranium nucleus, ${}^{238}_{92}\mathrm{U}$, emits an alpha particle and the resulting nucleus emits β-particle. What are the atomic number and mass number of final nucleus?

Q 29. How many electrons, protons and neutrons are there in a nucleus of atomic number 11 and mass number 24?

Q 30. Hydrogen atom in its ground state is excited by means of monochromatic radiation of wavelength 975 Å. How many different lines are possible in the resulting spectrum? Calculate the longest wavelength amongst them. You may assume the ionization energy for hydrogen atom as 13.6 eV.

Answers

1. A
2. A
3. A
4. D
5. B
6. C
7. B
8. B, D
9. A, B, C, D
10. C, D
11. F
12. F
13. F
14. 10 kg, 0.098 J
15. (a) $[ML^2T^{-1}Q^{-1}]$ (b) $[ML^{-1}T^{-2}]$
16. v, in the direction opposite to velocity of B.
17. Midway between A and B, 3.54 s
18. 0.628 s
19. Yes, in the direction opposite to A.
20. $(6.4\ \text{m}, 0, 0)$, $(6.4\ \text{m}, 0, 2$
21. 4.96 mA, 1.58 V
22. yes
23. 0.9 A
24. 27.04 N
25. $13.98\ \text{W/m}^2$
26. Hollow sphere
27. -972 J
28. 91, 234
29. zero, 11, 13
30. Six, 1.882 µm

IIT JEE 1981

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Paper

The paper contains questions of (1) single option correct type (2) true false type and (3) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. The half-life of the radioactive Radon is 3.8 days. The time, at the end of which 1/20 th of the Radon sample will remain undecayed, is [Given $\log_{10} e = 0.4343$.]

(A) 3.8 days (B) 16.5 days (C) 33 days (D) 76 days

Q 2. If the radius of the earth were to shrink by one per cent, its mass remaining the same, the acceleration due to gravity on the earth's surface would

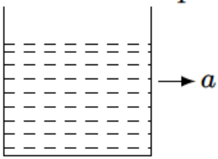
(A) decrease (B) remain unchanged

(C) increase (D) be zero

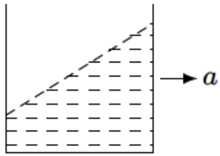
Q 3. The following four wires are made of the same material. Which of these will have the largest extension when the same tension is applied?
(A) Length $= 50$ cm, diameter $= 0.5$ mm
(B) Length $= 100$ cm, diameter $= 1$ mm
(C) Length $= 200$ cm, diameter $= 2$ mm
(D) Length $= 300$ cm, diameter $= 3$ mm

Q 4. A vessel containing water is given a constant acceleration a towards the right along a straight horizontal path. Which of the following diagrams represent the surface of the liquid?

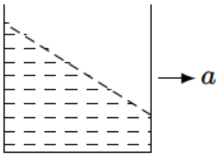
(A)



(B)



(C)

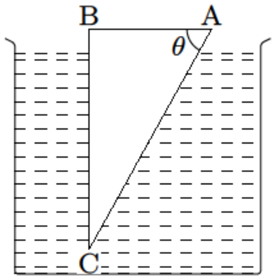


(D) None

Q 5. In Young's double slit experiment, the separation between the slits is halved and the distance between the slits and the screen is doubled. The fringe width is

(A) unchanged (B) halved
(C) doubled (D) quadrupled

Q 6. A glass prism of refractive index 1.5 is immersed in water (refractive index 4/3). A light beam incident normally on the face AB is totally reflected to reach the face BC if



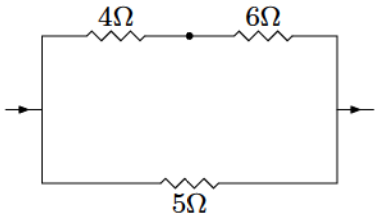
(A) $\sin\theta > 8/9$ (B) $2/3 < \sin\theta < 8/9$
(C) $\sin\theta < 2/3$ (D) None of these

Q 7. The plate resistance of a triode is $3 \times 10^3\ \Omega$ and its mutual conductance is 1.5×10^{-3} A/V. The amplification factor of the triode is
(A) 5×10^{-5} (B) 4.5 (C) 45 (D) 2×10^5

Q 8. A cylindrical tube, open at both ends, has a fundamental frequency f in air. The tube is dipped vertically in water so that half of its length is in water. The fundamental frequency of the air column is now
(A) $f/2$ (B) $3f/4$ (C) f (D) $2f$

Q 9. An alpha particle of energy 5 MeV is scattered through 180° by a fixed uranium nucleus. The distance of closest approach is of the order of
(A) 1 Å (B) 10^{-10} cm (C) 10^{-12} cm (D) 10^{-15} cm

Q 10. In the circuit shown in figure the heat produced in the $5\ \Omega$ resistor due to the current flowing through it is 10 cal/s. The heat generated in the $4\ \Omega$ resistor is



(A) 1 cal/s (B) 2 cal/s (C) 3 cal/s (D) 4 cal/s

True False Type

This section contains true false type questions.

Q 11. The work done in carrying a point charge from one point to another in an electrostatic field depends on the path along which the point charge is carried.

Q 12. When a person walks on a rough surface, the frictional force exerted by the surface on the person is opposite to the direction of his motion.

Q 13. No net force acts on a rectangular coil carrying a steady current when suspended freely in a uniform magnetic field.

Q 14. The kinetic energy of photoelectrons emitted by a photosensitive surface depends on the intensity of the incident radiation.

Q 15. The intensity of light at a distance r from the axis of a long cylindrical source is inversely proportional to r.

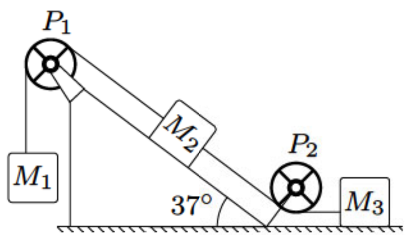
Descriptive

There are descriptive questions in this section. Solve all of them.

Q 16. An object is placed 21 cm in front of a concave mirror of radius of curvature 20 cm. A glass slab of thickness 3 cm and refractive index 1.5 is placed close to the mirror in the space between the object and the mirror. Find the position of the final image formed. The distance of the nearer surface of the slab from the mirror is 1.0 cm.

Q 17. A gas bubble, from an explosion under water, oscillates with a period T proportional to $p^a d^b E^c$, where p is the static pressure, d is the density of water and E is the total energy of the explosion. Find the values of a, b and c.

Q 18. Masses M_1, M_2 and M_3 are connected by strings of negligible mass which passes over massless and frictionless pulleys P_1 and P_2 as shown in figure. The masses move such that the portion of the string between P_1 and P_2 is parallel to the inclined plane and the portion of the string between P_2 and M_3 is horizontal. The masses M_2 and M_3 are 4.0 kg each and the coefficient of kinetic friction between the masses and the surface is 0.25. The inclined plane makes an angle of $37°$ with the horizontal. If the mass M_1 moves downwards with a uniform velocity, find, [Take $g = 9.8\ \mathrm{m/s^2}$, $\sin 37° \approx 3/5$.]



(a) the mass of M_1.
(b) the tension in the horizontal portion of the string.

Q 19. A lead bullet just melts when stopped by an obstacle. Assuming that 25 per cent of the heat is absorbed by the obstacle, find the velocity of the bullet if its initial temperature is 27 °C. [For lead, melting point = 327 °C, specific heat = 0.03 cal/g-°C, latent heat of fusion = 6 cal/g and $J = 4.2$ J/cal.]

Q 20. A body of mass 1 kg initially at rest, explodes and breaks into three fragments of masses in the ratio $1:1:3$. The two pieces of equal mass fly-off perpendicular to each other with a speed of 30 m/s each. What is the velocity of the heavier fragment?

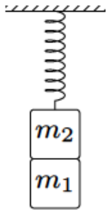
Q 21. A single electron orbits around a stationary nucleus of charge $+Ze$, where Z is a constant and e is the magnitude of the electronic charge. It requires 47.2 eV to excite the electron from the second Bohr orbit to the third Bohr orbit. Find,

(a) the value of Z.
(b) the energy required to excite the electron from the third to the fourth Bohr orbit.
(c) the wavelength of the electromagnetic radiation required to remove the electron from the first Bohr orbit to infinity.
(d) the kinetic energy, potential energy and the angular momentum of the electron in the first Bohr orbit.
(e) the radius of the first Bohr orbit.

[The ionization energy of hydrogen atom = 13.6 eV, velocity of light in vacuum = 3×10^{8} m/s, Bohr radius = 5.3×10^{-11} m, and Planck's constant = 6.6×10^{-34} J s.]

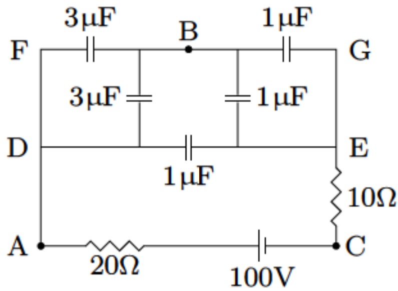
Q 22. An ideal gas is enclosed in a vertical cylindrical container and supports a freely moving piston of mass M. The piston and the cylinder have equal cross-sectional area A. Atmospheric pressure is p_0 and when the piston is in equilibrium, the volume of the gas is V. The piston is now displaced slightly from its equilibrium position. Assuming that the system is completely isolated from its surroundings, show that the piston executes SHM and find the frequency of oscillation.

Q 23. Two masses m_1 and m_2 are suspended together by a massless spring of spring constant k (see figure). When the masses are in equilibrium, m_1 is removed without disturbing the system. Find the angular frequency and the amplitude of oscillation of m_2.

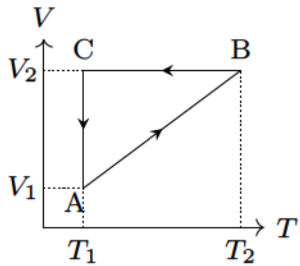


Q 24. Two identical cylindrical vessels with their bases at the same level, each contain a liquid of density ρ. The height of the liquid in one vessel is h_1 and in the other is h_2. The area of either base is A. What is the work done by gravity in equalising the levels when the two vessels are connected?

Q 25. Find the potential difference between the points A and B and between the points B and C in the steady state (see figure).

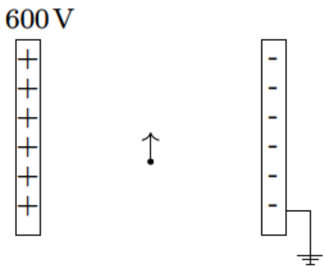


Q 26. A cyclic process ABCA shown in the V-T diagram is performed with a constant mass of an ideal gas. Show the same process on a p-V diagram. [In the figure, line AB passes through origin.]



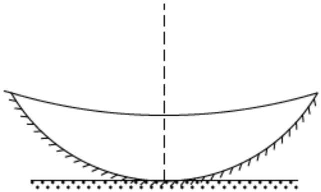
Q 27. The two rails of a railway track, insulated from each other and the ground, are connected to a millivoltmeter. What is the reading of the millivoltmeter when a train travels at a speed of 180 km/h along the track given that the vertical component of earth's magnetic field is 0.2×10^{-4} Wb/m^2 and the rails are separated by 1 m? Track is south to north.

Q 28. A potential difference of 600 V is applied across the plates of a parallel plate condenser. The separation between the plates is 3 mm. An electron projected vertically, parallel to the plates, with a velocity of 2×10^6 m/s moves un-deflected between the plates. Find the magnitude and direction of the magnetic field in the region between the condenser plates. [Charge of the electron $= 1.6 \times 10^{-9}$ C, Neglect the edge effects.]



Q 29. A charge Q is distributed over two concentric hollow spheres of radii r and $R(> r)$ such that the surface charge densities are equal. Find the potential at the common centre.

Q 30. The convex surface of a thin concavo-convex lens of glass of refractive index 1.5 has a radius of curvature 20 cm. The concave surface has a radius of curvature 60 cm. The convex side is silvered and placed on a horizontal surface.

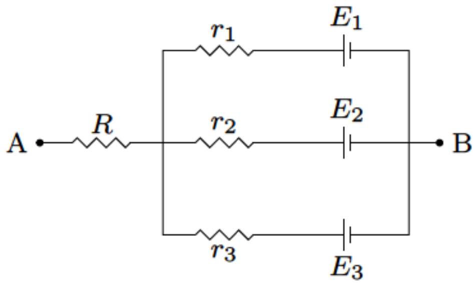


(a) Where should a pin be placed on the optic axis such that its image is formed at the same place?

(b) If the concave part is filled with water of refractive index 4/3, find the distance through which the pin should be moved, so that the image of the pin again coincides with the pin.

Q 31. A source of sound of frequency 256 Hz is moving rapidly towards a wall with a velocity of 5 m/s. How many beats per second will be heard by the observer on source itself if sound travels at a speed of 330 m/s?

Q 32. In the circuit shown in figure $E_1 = 3$ V, $E_2 = 2$ V, $E_3 = 1$ V and $R = r_1 = r_2 = r_3 = 1\ \Omega$.



(a) Find the potential difference between the points A and B and the currents through each branch.

(b) If r_2 is short circuited and the point A is connected to point B, find the currents through E_1, E_2, E_3 and the resistor R.

Answers

1. B
2. C
3. A
4. C
5. D
6. A
7. B
8. C
9. C
10. B
11. F
12. F
13. T
14. F
15. T
16. 21 cm
17. $a = -\frac{5}{6}$, $b = \frac{1}{2}$, $c = \frac{1}{3}$
18. (a) 4.2 kg (b) 9.8 N
19. 409.8 m/s
20. $10\sqrt{2}$ m/s at 45°
21. (a) 5 (b) 16.53 eV (c) 36.53 Å (d) 340 eV, −680 eV, −340 eV, 1.05×10^{-34} kg m^{2}s^{-1} (e) 1.06×10^{-11} m
22. $\frac{A}{2\pi}\sqrt{\frac{\gamma(p_0+Mg/A)}{MV}}$
23. $\omega = \sqrt{\frac{k}{m_2}}$, $A = \frac{m_1 g}{k}$
24. $\frac{\rho A g}{4}(h_1 - h_2)^2$
25. $V_{\mathrm{AB}} = 25$ V, $V_{\mathrm{BC}} = 75$ V
26. See solution
27. 1 mV
28. 0.1 T, perpendicular to paper inwards
29. $\frac{Q(R+r)}{4\pi\epsilon_0(R^2+r^2)}$
30. (a) 15 cm (b) 1.16 cm (downwards)
31. 7.88 Hz
32. (a) 2 V, 1 A, 0, −1 A (b) 1 A, 2 A, −1 A, 2 A

IIT JEE 1980

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Paper

The paper contains questions of (1) single option correct type and (2) descriptive type.

One Option Correct

Each question in this section has four options (A), (B), (C) and (D). Only one of these four options is correct.

Q 1. When a ray of light enters a glass slab from air,

(A) its wavelength decreases.

(B) its wavelength increases.

(C) its frequency increases.

(D) neither its wavelength nor its frequency changes.

Q 2. A metal ball immersed in alcohol weighs W_1 at $0\,°C$ and W_2 at $50\,°C$. The coefficient of cubical expansion of the metal is less than that of the alcohol. Assuming that the density of the metal is large compared to that of alcohol, it can be shown that

(A) $W_1 > W_2$ (B) $W_1 = W_2$

(C) $W_1 < W_2$ (D) All of these

Q 3. If a machine is lubricated with oil,

(A) the mechanical advantage of the machine increases.

(B) the mechanical efficiency of the machine increases.

(C) both its mechanical advantage and mechanical efficiency increases.

(D) its efficiency increases, but its mechanical advantage decreases.

Q 4. Two masses of 1 g and 4 g are moving with equal kinetic energies. The ratio of the magnitude of their momentum is
(A) $4:1$ (B) $\sqrt{2}:1$ (C) $1:2$ (D) $1:16$

Q 5. A ship of mass 3×10^7 kg initially at rest, is pulled by a force of 5×10^4 N through a distance of 3 m. Assuming that the resistance due to water is negligible, the speed of the ship is
(A) 1.5 m/s (B) 60 m/s (C) 0.1 m/s (D) 5 m/s

Q 6. A block of mass 2 kg rests on a rough inclined plane making an angle of $30°$ with the horizontal. The coefficient of static friction between the block and the plane is 0.7. The frictional force on the block is

(A) 9.8 N (B) $0.7 \times 9.8 \times \sqrt{3}$ N

(C) $9.8 \times \sqrt{3}$ N (D) 0.7×9.8 N

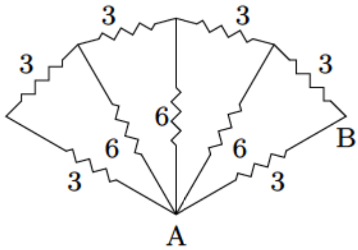
Descriptive

There are descriptive questions in this section. Solve all of them.

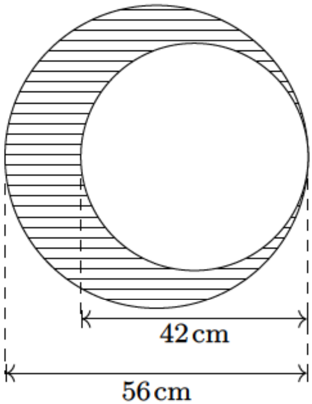
Q 7. A telescope has an objective of focal length 50 cm and an eyepiece of focal length 5 cm. The least distance of distinct vision is 25 cm. The telescope is focussed for distinct vision on a scale 200 cm away from the objective. Calculate (a) the separation between the objective and the eyepiece, and (b) the magnification produced by the telescope.

Q 8. A rectangular block of glass is placed on a printed page lying on a horizontal surface. Find the minimum value of the refractive index of glass for which the letters on the page are not visible from any of the vertical faces of the block.

Q 9. All resistances in the figure are in Ω. Find the effective resistance between the points A and B.



Q 10. A circular plate of uniform thickness has a diameter of 56 cm. A circular portion of diameter 42 cm is removed from one edge of the plate as shown in the figure. Find the position of the centre of mass of the remaining portion.

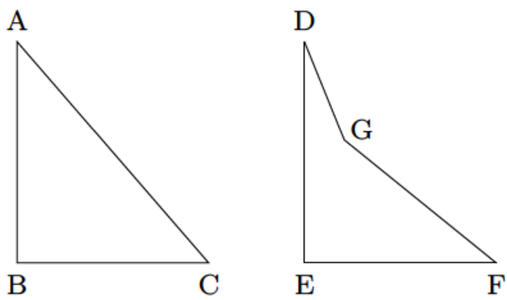


Q 11. The displacement x of a particle moving in one dimension, under the action of a constant force is related to the time t by the equation $t = \sqrt{x} + 3$, where x is in metre and t in second. Find,

(a) The displacement of the particle when its velocity is zero, and

(b) The work done by the force in the first 6 s.

Q 12. In the figure (a) and figure (b) AC, DG and GF are fixed inclined planes, BC = EF = x and AB = DE = y. A small block of mass m is released from the point A. It slides down AC and reaches C with a speed v_C. The same block is released from rest from the point D. It slides down DGF and reaches the point F with speed v_F. The coefficients of kinetic frictions between the block and both the surfaces AC and DGF are μ. Calculate v_C and v_F.



(a) (b)

Q 13. A body of mass 2 kg is being dragged with a uniform velocity of 2 m/s on a rough horizontal plane. The coefficient of friction between the body and the surface is 0.20. Calculate the amount of heat generated in 5 s. [Given $J = 4.2$ J/cal and $g = 9.8\ \mathrm{m/s^2}$.]

Q 14. Give MKS units for (a) Young's modulus, (b) magnetic induction, and (c) power of a lens.

Answers

1. A
2. C
3. B
4. C
5. C
6. A
7. (a)70.73 cm (b) $m = -2$
8. $\sqrt{2}$
9. $2\,\Omega$
10. 9 cm from centre of bigger circle
11. (a) zero (b) zero
12. $v_C = v_F = \sqrt{2(gy - \mu gx)}$
13. 9.33 cal
14. (a) N/m^2(b) Tesla (c) m^{-1}

IIT JEE 1979

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Paper

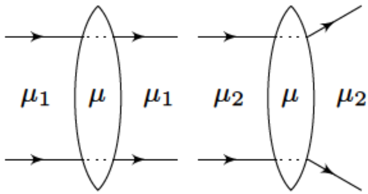
The paper contains descriptive questions.

Descriptive

There are descriptive questions in this section. Solve all of them.

Q 1. A composite rod is made by joining a copper rod, end to end, with a second rod of different material but of the same cross-section. At 25 °C, the composite rod is 1 m in length, of which the length of the copper rod is 30 cm. At 125 °C the length of the composite rod increases by 1.91 mm. When the composite rod is not allowed to expand by holding it between two rigid walls, it is found that the length of the two constituents do not change with rise in temperature. Find the Young's modulus and the coefficient of linear expansion of the second rod. [For copper, coefficient of linear expansion $= 1.7 \times 10^{-5}$ /°C, Young's modulus $= 1.3 \times 10^{11}$ N/m^2.]

Q 2. What is the relation between the refractive indices μ_1 and μ_2? If the behaviour of the light rays is as shown in the figure.



Q 3. The radius of curvature of the convex face of a plano-convex lens is 12 cm and its refractive index $\mu = 1.5$.

(a) Find the focal length of the lens.

(b) The plane face of the lens is now silvered. At what distance from the lens will parallel rays incident on the convex surface converge?

(c) Sketch the ray diagram to locate the image, when a point object is placed on the axis 20 cm from the lens.

(d) Calculate the image distance when the object is placed as in (c) above.

Q 4. A copper wire is held at the two ends by rigid supports. At 30 °C, the wire is just taut, with negligible tension. Find the speed of transverse waves in this wire at 10 °C. [Given, for copper: Young's modulus $= 1.3 \times 10^{11}$ N/m^2, coefficient of linear expansion $= 1.7 \times 10^{-5}$ °C^{-1}, density $= 9 \times 10^3$ kg/m^3.]

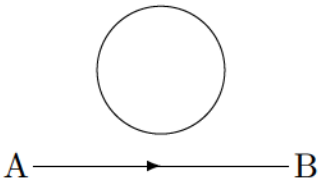
Q 5. A 25 W and a 100 W bulb are joined in series and connected to the mains. Which bulb will glow brighter?

Q 6. A copper wire having cross-sectional area of $0.5\ \text{mm}^2$ and a length of 0.1 m is initially at $25\ ^\circ\text{C}$ and is thermally insulated from the surroundings. If a current of 1.0 A is set up in this wire, (a) find the time in which the wire will start melting. The change of resistance with the temperature of the wire may be neglected. (b) What will this time be, if the length of the wire is doubled? [For Copper, Melting point $= 1075\ ^\circ\text{C}$, Specific resistance $= 1.6 \times 10^{-8}\ \Omega$ m, Density $= 9 \times 10^3\ \text{kg/m}^3$, Specific heat $= 9 \times 10^{-2}$ cal/(kg $^\circ$C).]

Q 7. A charged particle is free to move in an electric field. It will always move along an electric line of force.

Q 8. A pendulum bob of mass 80 mg and carrying a charge of 2×10^{-8} C is at rest in a horizontal uniform electric field of 20000 V/m. Find the tension in the thread of the pendulum and the angle it makes with the vertical. [Take $g = 9.8\ \mathrm{m/s^2}$.]

Q 9. A current from A to B is increasing in magnitude. What is the direction of induced current in the loop as shown in the figure?

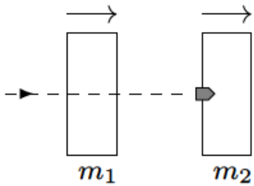


Q 10. A boat floating in a water tank is carrying a number of large stones. If the stones are unloaded into water, then water level will rises up?

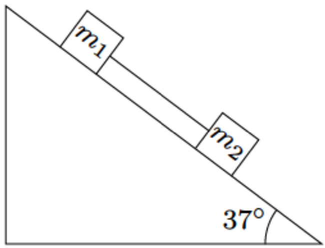
Q 11. A mass m attached to a spring oscillates with a period of 2 s. If the mass is increased by 2 kg the period increases by 1 s. Find the initial mass m assuming Hooke's law is obeyed.

Q 12. When a ball is thrown up, the magnitude of its momentum decreases and then increases. Does this violate the conservation of momentum principle?

Q 13. A 20 g bullet pierces through a plate of mass $m_1 = 1$ kg and then comes to rest inside a second plate of mass $m_2 = 2.98$ kg as shown in the figure. It is found that the two plates initially at rest, now move with equal velocities. Find the percentage loss in the initial velocity of the bullet when it is between m_1 and m_2. Neglect any loss of material of the plates due to the action of bullet. Both plates are lying on smooth table.



Q 14. Two blocks connected by a massless string slides down an inclined plane having an angle of inclination of $37°$. The masses of the two blocks are $m_1 = 4$ kg and $m_2 = 2$ kg respectively and the coefficients of friction of m_1 and m_2 with the inclined plane are 0.75 and 0.25 respectively. Assuming the string to be taut, find (a) the common acceleration of two masses, and (b) the tension in the string. [Take $\sin 37° = 0.6$, $\cos 37° = 0.8$, $g = 9.8\ \mathrm{m/s^2}$.]



Answers

1. 1.105×10^{11} N/m^2, 2×10^{-5} /°C

2. $\mu_1 < \mu_2$

3. (a) 24 cm (b) 12 cm (d) $v = -30$ cm

4. 70.08 m/s

5. 25 W

6. (a) 55.55 s (b) 55.55 s

7. F

8. 8.8×10^{-4} N, 27°

9. Clockwise

10. F

11. 1.6 kg

12. No

13. 25%

14. (a) 1.3 m/s^2 (b) 5.2 N

IIT JEE 1978

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Paper

The paper contains descriptive questions.

Descriptive

There are descriptive questions in this section. Solve all of them.

Q 1. A sinker of weight W_0 has an apparent weight W_1 when placed in a liquid at a temperature T_1 and W_2 when weighed in the same liquid at temperature T_2. The coefficient of cubical expansion of the material of the sinker is β. What is the coefficient of volume expansion of the liquid?

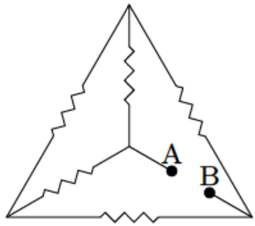
Q 2. A room is maintained at 20 °C by a heater of resistance 20 Ω connected to 200 V mains. The temperature is uniform throughout the room and the heat is transmitted through a glass window of area 1 m^2 and thickness 0.2 cm. Calculate the temperature outside. Thermal conductivity of glass is 0.2 cal $m^{-1}s^{-1}{}^\circ C^{-1}$ and mechanical equivalent of heat is 4.2 J/cal.

Q 3. A ray of light is incident at an angle of $60°$ on one face of a prism which has an angle of $30°$. The ray emerging out of the prism makes an angle of $30°$ with the incident ray. Show that the emergent ray is perpendicular to the face through which it emerges and calculate the refractive index of the material of the prism.

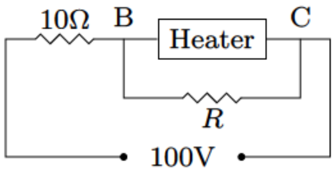
Q 4. A pin is placed 10 cm in front of a convex lens of focal length 20 cm and made of a material of refractive index 1.5. The convex surface of the lens farther away from the pin is silvered. Determine the position of the final image. Is the image real or virtual?

Q 5. A copper wire is stretched to make it 0.1% longer. What is the percentage change in its resistance?

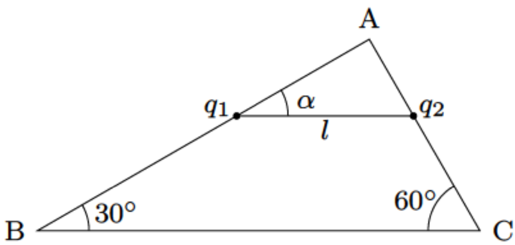
Q 6. If each of the resistances in the network shown in the figure is R, what is the resistance between the terminals A and B?



Q 7. A heater is designed to operate with a power of 1000 W in a 100 V line. It is connected in combination with a resistance of 10 Ω and a resistance R, to a 100 V mains as shown in the figure. What will be the value of R so that the heater operates with a power of 62.5 W?



Q 8. A rigid insulated wire frame in the form of a right angled triangle ABC, is set in a vertical plane as shown in the figure. Two beads of equal masses m each and carrying charges q_1 and q_2 are connected by a cord of length l and can slide without friction on the wires. Considering the case when the beads are stationary determine,



(a) (i) The angle α.
(ii) The tension in the cord.
(iii) The normal reaction on the beads.

(b) If the cord is now cut what are the values of the charges for which the beads continue to remain stationary?

Q 9. A column of mercury of length 10 cm is contained in the middle of a horizontal tube of length 1 m which is closed at both the ends. The two equal lengths contain air at standard atmospheric pressure of 0.76 m of mercury. The tube is now turned to vertical position. By what distance will the column of mercury be displaced? Assume temperature to be constant.

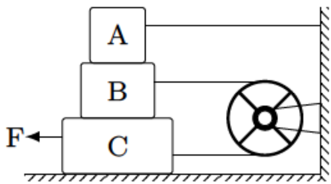
Q 10. A point mass m is suspended at the end of massless wire of length l and cross-sectional area A. If Y is the Young's modulus of elasticity of the material of the wire, obtain the expression for the frequency of the SHM along the vertical line.

Q 11. A body of mass m moving with a velocity v in the x direction collides with another body of mass M moving in the y direction with velocity V. They coalesce into one body during collision. Find,

(a) The direction and magnitude of the momentum of the composite body.

(b) The fraction of the initial kinetic energy transformed into heat during the collision.

Q 12. In the figure, the blocks A, B and C have masses 3 kg, 4 kg and 8 kg respectively. The coefficient of sliding friction between any two surfaces is 0.25. A is held at rest by a massless rigid rod fixed to the wall, while B and C are connected by a light flexible cord passing around a fixed frictionless pulley. Find the force F necessary to drag C along the horizontal surface to the left at a constant speed. Assume that the arrangement shown in the figure *i.e.*, B on C and A on B, is maintained throughout. [Take $g = 10$ m/s^2.]



Q 13. A uniform rope of length L and mass M lying on a smooth table is pulled by a constant force F. What is the tension in the rope at a distance l from the end where the force is applied?

Q 14. A block of mass 2 kg slides on an inclined plane which makes an angle of 30° with the horizontal. The coefficient of friction between the block and the surface is $\sqrt{3}/\sqrt{2}$. What force along the plane should be applied to the block so that it moves (a) down, and (b) up, without any acceleration? [Take $g = 10$ m/s^2.]

Answers

1. $\beta\left(\frac{W_0-W_1}{W_0-W_2}\right)+\frac{W_2-W_1}{(W_0-W_2)(T_2-T_1)}$

2. 15.24 °C

3. $\mu=\sqrt{3}$

4. 10 cm, real

5. 0.2% increase

6. R

7. 5 Ω

8. (a) (i) 60° (ii) $\frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{l^2}+mg$ (iii) $\sqrt{3}mg$, mg (b) $q_1q_2=-4\pi\epsilon_0 mgl^2$

9. 2.96 cm

10. $\nu=\frac{1}{2\pi}\sqrt{\frac{YA}{ml}}$

11. (a) $\tan^{-1}\left(\frac{MV}{mv}\right)$ with $+x$, $\sqrt{(mv)^2+(MV)^2}$ (b) $\frac{Mm(v^2+V^2)}{(m+M)(mv^2+MV^2)}$

12. 80 N

13. $F\left(1-\frac{l}{L}\right)$

14. (a) 11.21 N (b) 31.21 N